TOPE-3
A-1
5 AUG 3

ANNALS
of the Association of American Geographers

INDEX TO VOLUME XLVI, 1956

Prepared and donated by JOHANNA KOLLMORGEN

WALTER M. KOLLMORGEN
Editor

G80
A849a
v. 46-47

Feb 1, 1960
B.P.

TABLE OF CONTENTS

Page

Southern Rhodesia—An African Compage ..... Derwent Whittlesey 1
Mangrove Swamps of the Pacific Coast of Colombia ..... Robert C. West 98
Cultural Factors in the Location of the Swatow Lace and Needlework Industry 98
Theodore Herman 122
Influence of Underlying Rock Structures on Stream Courses and Valley Profiles in the Georgia Piedmont
James F. Woodruff and Eldon J. Parizek 129
The United States in Professional Geographic Literature ..... H. F. Raup 140
Extended Uses of Polyconic Projection Tables ..... John Leighly 150
Book Review Statement ..... Review Editor and Editor 174
Manufacturing Industry in Belfast, Northern Ireland .... Morgan D. Thomas 175
Man as a Geomorphological Agent: The Example of Coal Mining
Arthur Doerr and Lee Guernsey 197
The Nature and Origin of the Canadian Dry Belt ..... Jack R. Villmow 211
The Necessity of Weighting Values in Correlation Analysis of Areal Data
Arthur H. Robinson 233
Abstracts of Papers Presented at the 52nd Annual Meeting of the Association of American Geographers, Montreal, Canada, April 1–5, 1956 237
Book Reviews
Raye R. Platt, ed.: Finland and Its Geography .... Eugene Van Cleef 285
The Education of a Geographer ..... Carl O. Sauer 287
The Water Balance of India According to Thornthwaite's Concept of Potential Evapotranspiration ..... V. P. Subrahmanyam 300
Circulation and Settlement Patterns of the Calumet Region of Northwest Indiana and Northeast Illinois (The Second Stage of Occupance—Pioneer Settler and Subsistence Economy, 1830–1850) ..... Alfred H. Meyer 312
Lawrence Martin, 1880–1955 ..... Frank E. Williams 357
Book Reviews
Stephen Sargent Visher: Climatic Atlas of the United States
Wesley Calef 365
W. S. Woytinsky and E. S. Woytinsky: World Population and Production: Trends and Outlook *and* World Commerce and Governments: Trends and Outlook ..... Wilbur Zelinsky 365
Paul F. Lazarsfeld and Morris Rosenberg, eds.: The Language of Social Research: A Reader in the Methodology of Social Research
William L. Garrison 367
Cause and Effect in Human Geography ..... Emrys Jones 369
The Agricultural Background of Settlement in Eastern Nova Scotia
R. Louis Gentilcore 378

Durum Wheat and the Expansion of Dry Farming in the Soviet Union
W. A. DOUGLAS JACKSON 405
Changing Significance of Environmental Factors at Bloomington, Indiana
STEPHEN S. VISHER 411
Book Reviews
George F. Cressey: Land of the 500 Million
Theodore Shabad: China's Changing Map, A Political and Economic Geography of the Chinese Republic
W. W. Rosow and Associates: The Prospects for Communist China
Yuan-li Wu: An Economic Survey of Communist China
Richard L. Walker: China Under Communism, The First Five Years
S. B. Thomas: Government and Administration in Communist China
J. E. SPENCER 417
Table of Contents, Volume XLVI, 1956 423
Index, Volume XLVI, 1956 425

INDEX

Articles

PAGE

Agricultural Background of Settlement in Eastern Nova Scotia, The, by R. Louis Gentilcore
Belfast, Northern Ireland, Manufacturing Industry in, by Morgan D. Thomas 175
Bloomington, Indiana, Changing Significance of Environmental Factors at, by Stephen S. Visher .....
Calumet Region of Northwest Indiana and Northeast Illinois, Circulation and Settlement Patterns of the (The Second State of Occupance—Pioneer Settler and Subsistence Economy, 1830–1850), by Alfred H. Meyer 312
Canadian Dry Belt, The Nature and Origin of the, by Jack R. Villmow 211
Circulation and Settlement Patterns of the Calumet Region of Northwest Indiana and Northeast Illinois (The Second Stage of Occupance—Pioneer Settler and Subsistence Economy, 1830–1850), by Alfred H. Meyer 312
Coal Mining, Man as a Geomorphological Agent: The Example of, by Arthur Doerr and Lee Guernsey 197
Correlation Analysis of Areal Data, The Necessity of Weighting Values in, by Arthur H. Robinson 233
Cultural Factors in the Location of the Swatow Lace and Needlework Industry, by Theodore Herman 122
DOERR, ARTHUR, and LEE GUERNSEY, Man as a Geomorphological Agent: The Example of Coal Mining 197
Dry Farming in the Soviet Union, Durum Wheat and the Expansion of, by W. A. Douglas Jackson 405
Education of a Geographer, The, by Carl O. Sauer 287
Environmental Factors at Bloomington, Indiana, Changing Significance of, by Stephen S. Visher 411
GENTILCORE, R. LOUIS, The Agricultural Background of Settlement in Eastern Nova Scotia 378
Geomorphological Agent: The Example of Coal Mining, Man as a, by Arthur Doerr and Lee Guernsey 197
Georgia Piedmont, Influence of Underlying Rock Structures on Stream Courses and Valley Profiles in the, by Eldon J. Parizek and James F. Woodruff 129
GUERNSEY, LEE, and ARTHUR DOERR, Man as a Geomorphological Agent: The Example of Coal Mining 197
HERMAN, THEODORE, Cultural Factors in the Location of the Swatow Lace and Needlework Industry 122
Human Geography, Cause and Effect in, by Emrys Jones 369
India According to Thornthwaite's Concept of Potential Evapotranspiration, The Water Balance of, by V. P. Subrahmanyam 300
JACKSON, W. A. DOUGLAS, Durum Wheat and the Expansion of Dry Farming in the Soviet Union 405
JONES, EMRYS, Cause and Effect in Human Geography 369
LEIGHLY, JOHN, Extended Uses of Polyconic Projection Tables 150
Mangrove Swamps of the Pacific Coast of Colombia, by Robert C. West 98
Manufacturing Industry in Belfast, Northern Ireland, by Morgan D. Thomas 175
Martin, Lawrence, 1880–1955, by Frank E. Williams 357

MEYER, ALFRED H., Circulation and Settlement Patterns of the Calumet Region of Northwest Indiana and Northeast Illinois (The Second Stage of Occupance—Pioneer Settler and Subsistence Economy, 1830–1850) 312
Nova Scotia, The Agricultural Background of Settlement in Eastern, by R. Louis Gentilcore 378
PARIZEK, ELDON J., and JAMES F. WOODRUFF, Influence of Underlying Rock Structures on Stream Courses and Valley Profiles in the Georgia Piedmont 129
Polyconic Projection Tables, Extended Uses of, by John Leighly 150
SAUER, CARL O., The Education of a Geographer 287
RAUP, H. F., The United States in Professional Geographic Literature 140
Rhodesia—An African Compage, Southern, by Derwent Whittlesey 1
ROBINSON, ARTHUR H., The Necessity of Weighting Values in Correlation Analysis of Areal Data 233
Southern Rhodesia—An African Compage, by Derwent Whittlesey 1
Stream Courses and Valley Profiles in the Georgia Piedmont, Influence of Underlying Rock Structures on, by Eldon J. Parizek and James F. Woodruff 129
SUBRAHMANYAM, V. P., The Water Balance of India According to Thornthwaite's Concept of Potential Evapotranspiration 300
Swatow Lace and Needlework Industry, Cultural Factors in the Location of the, by Theodore Herman 122
THOMAS, MORGAN D., Manufacturing Industry in Belfast, Northern Ireland 175
United States in Professional Geographic Literature, The, by H. F. Raup 140
Valley Profiles in the Georgia Piedmont, Influence of Underlying Rock Structures on Stream Courses and, by Eldon J. Parizek and James F. Woodruff 129
VILLMOW, JACK R., The Nature and Origin of the Canadian Dry Belt 211
VISHER, STEPHEN S., Changing Significance of Environmental Factors at Bloomington, Indiana 411
Water Balance of India According to Thornthwaite's Concept of Potential Evapotranspiration, The, by V. P. Subrahmanyam 300
Weighting Values in Correlation Analysis of Areal Data, The Necessity of, by Arthur H. Robinson 233
WEST, ROBERT C., Mangrove Swamps of the Pacific Coast of Colombia 98
Wheat and the Expansion of Dry Farming in the Soviet Union, Durum, by W. A. Douglas Jackson .....
WHITTLESEY, DERWENT, Southern Rhodesia—An African Compage 1
WILLIAMS, FRANK E., Lawrence Martin, 1880–1955 357
WOODRUFF, JAMES F., and ELDON J. PARIZEK, Influence of Underlying Rock Structures on Stream Courses and Valley Profiles in the Georgia Piedmont 129

Abstracts of Papers Presented at the 52nd Annual Meeting of the Association of American Geographers, Montreal, Canada, April 1–5, 1956

Agricultural Land and Buildings in Northeastern United States, The Areal Variation in the Value of, by John C. Hook 252
Agriculture in Southern Japan, Urban, by John H. Thompson 277
Agriculture in the Vincennes Area, Indiana, 1735–1830, Early, by R. Louis Gentilcore 247
Agriculture, Recent Changes in British, by John Fraser Hart 250
Aircraft Manufacturing in Texas, by Tom L. McNight 263
ALEXANDER, CHARLES S., Effects of a Pastoral Economy upon the Vegetation of a Desert Island 237
ALEXANDER, JOHN W., United States Cities: Employment Category by Size of Settlement 237

Aligarh, U. P., India, Historical and Cultural Influences on the Land-Use Pattern of, by Howard F. Hirt 251
Arctic Program, The McGill University-Arctic Institute Carnegie, by Svenn Orvig 267
Arctic Research Program of the Office of Naval Research, The, by Louis O. Quam 269
Athens: Its Evolution and Functions, Modern, by Huey Louis Kostanick 258
AUGELLI, JOHN P., Aspects of Industrial Genesis in an Underdeveloped Area: Post-War Development in Puerto Rico 238
BACON, H. PHILLIP, The Townscape of Nashville, Tennessee, on the Eve of the Civil War 238
BALLABON, MAURICE BERNARD, Some Aspects of Contemporary Economic Geography 239
Barbados, B.W.I., Standing Room Only: The Population Anomaly of, by David Lowenthal 260
Bauxite Operations on Jamaica, B.W.I., The Impact of, by Peter M. Stern 273
BERMAN, MILDRED, What Geographers Are Doing in Business: A Case History 239
Braunschweig Industrial Area, The, by Robert E. Dickinson 244
Business: A Case History, What Geographers Are Doing in, by Mildred Berman 239
CARLSON, ALBERT S., Non-Geographic Factors in Resource Development: Illustrations from New England 240
CHANG, CHING CHIEH, The Chinese in Cuba and Jamaica: A Comparative Geographical Study 240
Chinese in Cuba and Jamaica: A Comparative Geographical Study, The, by Ching Chieh Chang 240
Cities: Employment Category by Size of Settlement, United States, by John W. Alexander 237
City Management, Community Planning, and Urban Renewal, Evolving Acceptance of Geographic Thinking in, by Peter H. Nash 266
City Planning in Japan, The Nature and Function of, by David H. Kornhauser 257
CLARK, ANDREW H., Use of a "Control Area" to Test Hypotheses in Broader Regional Studies 241
Climatological Atlas Project of the World Meteorological Organization, The, by C. Warren Thornthwaite 278
COULTER, JOHN WESLEY, Economic Crisis in Hawaii 241
Crop Combinations in the North American Northeast, by Henry Madison Kendall 255
Culture, Notes on the Concept of, by William L. Thomas 276
CUTSHALL, ALDEN, The Philippine Sugar Industry: Foundations and Prospects 242
DALRYMPLE, PAUL C., Recent Developments in North Atlantic Ocean Weather Program 242
Danish-American Virgin Islands: The Changing Economy, The, by Mazie O. Tyson 278
DANSEREAU, PIERRE, Criteria for a Regional Description and Interpretation of Vegetation 243
Desert Boom in the Southwest, Suburbia in the Sun—the, by Richard F. Logan 259
Deserts and Oases, The American Concept of, by Benjamin E. Thomas 276
DESHLER, WALTER W., The Study of Indigenous Population Distribution in a Semi-arid East African Area 243
DICKINSON, ROBERT E., The Braunschweig Industrial Area 244
Distributions, A Method for Expressing Quantitatively the Correspondence of Mapped, by Arthur H. Robinson 270
DOHRS, FRED E., Heartland and World Ocean: A View of Soviet Geopolitical Theory 244
Economic Geography, Some Aspects of Contemporary, by Maurice Bernard Ballabon 239
Edmonton, Alberta, Repercussions of War and Oil on, by William C. Wonders 282
EISEN, EDNA E., Liebbecke in Westfalia: A Community Study 245
Energy Potential of Soviet Russia's Coal Fields, The, by Jordan A. Hodgkins 251
Environmental Influences at Bloomington, Indiana, Changing Significance of, by Stephen S. Visher 279

FIRMAN, DAVID, Current Expansion of Irrigation to Increase Food Production in the Gangetic Plain 246
FISCHER, ERIC, Some Comments on a Geography of Religions 246
Foreign-Trade Zone (Free Port)) on the Great Lakes-St. Lawrence Seaway? A, by Richard S. Thoman 275
Forest Geography of the Peninsula of Labrador-Ungava: Report on a Program of 1 to 1,000,000 Aerial Survey, by F. K. Hare 249
GENTILCORE, R. LOUIS, Early Agriculture in the Vincennes Area, Indiana, 1735–1830 247
Geomorphology, Basic Principles of Quantitative, by Arthur N. Strahler 275
Germanium and Gallium: A Study of Some Economic Aspects of Two Rare Metals, by Mary Megee 264
GIBSON, J. SULLIVAN, The Land-Use Type as a Geographical Tool 247
GOLOMB, BERL, Reclamation and Utilization of an Apparent Wasteland 248
Great Plains, Five Major Ranch Types of the Central, by Eugene Cotton Mather 262
Greenland, Recent Economic Developments in the Godthaab District, by Donn K. Haglund 248
Guatemala's Alta Verapaz—An Interim Report, Emerging Land Patterns in, by Frank L. Keller 254
HAGLUND, DONN K., Recent Economic Developments in the Godthaab District, Greenland 248
Halifax and St. John, The External Port Relations of, by Donald J Patton 269
HANLON, ELEANOR E., Twenty Years of Change in a Portion of the Rural-Urban Fringe of Syracuse, New York 249
HARE, F. K., The Forest Geography of the Peninsula of Labrador-Ungava: Report on a Program of 1 to 1,000,000 Aerial Survey 249
HART, JOHN FRASER, Recent Changes in British Agriculture 250
Hawaii, Economic Crisis in, by John Wesley Coulter 241
Heartland and World Ocean: A View of Soviet Geopolitical Theory, by Fred E. Dohrs .. 244
HERBERT, C. H., The Development of Transportation in Northern Canada 250
HIRT, HOWARD F., Historical and Cultural Influences on the Land-Use Pattern of Aligarh, U.P., India 251
HODGKINS, JORDAN A., The Energy Potential of Soviet Russia's Coal Fields 251
HOFFMAN, GEORGE W., The Role of Nuclear Power in Europe's Future Energy Supply 252
HOOK, JOHN C., The Areal Variation in the Value of Agricultural Land and Buildings in Northeastern United States 252
HOUK, RICHARD J., Some Significant Aspects of Portugal's Fishing Industry 253
Housing, Kansas City, Missouri, The Distribution of Substandard, Duane S. Knos 257
Human and Cultural Geography, Significant Tempero-Spatial Elements of, by Henry J. Warman 280
Indian Cities, The External Forms of, by Pradyumna P. Karan 254
Irish National Electrification Scheme, The, by Albert J. P. McCarthy 262
Irrigation to Increase Food Production in the Gangetic Plain, Current Expansion of, by David Firman 246
JACKSON, W. A. DOUGLAS, Durum Wheat: A Struggle for an Essential Food in the USSR 254
KARAN, PRADYUMNA, P., The External Forms of Indian Cities 254
KELLER, FRANK L., Emerging Land Patterns in Guatemala's Alta Verapaz—An Interim Report 254
KENDALL, HENRY MADISON, Crop Combinations in the North American Northeast 255
KLIMM, LESTER E., Regional Description Based on Texture and Pattern of Unit Areas 256
KLINE, HIBBERD V. B., Jr., Dynamics of the Geography of Rice in Sierra Leone, West Africa 256
KNOS, DUANE S., The Distribution of Substandard Housing, Kansas City, Missouri 257
KORNHAUSER, DAVID H., The Nature and Function of City Planning in Japan 257

KOSTANICK, HUEY LOUIS, Modern Athens: Its Evolution and Functions 258
KÜCHLER, A. W., Vegetation Maps in Geographical Research 258
Labor Migration, A Case Study of Interregional, by John L. Thompson 277
Lake Michigan in the Orchard and Vineyard Fruit Industry, The Role of, by Clarence W. Olmstead 267
Lakes of the Liverpool Bay Area, N.W.T., Canada, Oriented, by J. Ross Mackay 261
Landscape and Climate: Topographic Influences on Heat Supply at the Earth's Surface, by David H. Miller 265
Land-Use Type as a Geographical Tool, The, by J. Sullivan Gibson 247
Lappland: Northern Europe's Strategic Problem Area, by Vincent H. Malmström 261
Liebbecke in Westfalia: A Community Study, by Edna E. Eisen 245
LINEHAN, URBAN J., Areal Distribution of Tornado Deaths in the United States 259
Littorals, A Comparative Analysis of the Dry Western, by Paul E. Lydolph 260
Locational Changes in the Broad Woven Fabrics and Narrow Fabrics Industries between 1945 and 1955 in Pennsylvania Counties of the Philadelphia Standard Metropolitan Area, An Analysis of, by Robert M. Sparks 272
LOGAN, RICHARD F., Suburbia in the Sun—the Desert Boom in the Southwest 259
LOWENTHAL, DAVID, Standing Room Only: the Population Anomaly of Barbados, B.W.I. 260
LYDOLPH, PAUL E., A Comparative Analysis of the Dry Western Littorals 260
MACKAY, J. ROSS, Oriented Lakes of the Liverpool Bay Area, N.W.T., Canada 261
MALSTRÖM, VINCENT H., Lappland: Northern Europe's Strategic Problem Area ... 261
Manufacturing Activity, A Method for Measuring Change in the Relative Distribution of, by Wilbur Zelinsky 283
Maps for Landform Study by the Use of Statistical Inference, Increasing the Value of Small-scale, by Walter F. Wood 282
MATHER, EUGENE COTTON, Five Major Ranch Types of the Central Great Plains .. 262
McCARTHY, ALBERT J. P., The Irish National Electrification Scheme 262
McCARTY, HAROLD H., Use of Certain Statistical Procedures in Geographic Analysis 263
McNIGHT, TOM L., Aircraft Manufacturing in Texas 263
MEGEE, MARY, Germanium and Gallium: A Study of Some Economic Aspects of Two Rare Metals 264
MELAMID, ALEXANDER, The Impact of the St. Lawrence Seaway on the Economy of Cleveland (Ohio) 264
Mexico City Picnic Area: A Study in Recreational Geography, The, by Rayfred L. Stevens 274
Mineral Production and Contemporary Geopolitical Patterns, by Laurence Grambow Wolf 281
Mineral Supplies, Changing Sources of United States, by Howard G. Roepke 271
MILLER, DAVID H., Landscape and Climate: Topographic Influences on Heat Supply at the Earth's Surface 265
MURRAY, MALCOLM A., An Exploratory Study in Urban Medical Geography 265
NASH, PETER H., Evolving Acceptance of Geographic Thinking in City Management, Community Planning, and Urban Renewal 266
Nashville, Tennessee, on the Eve of the Civil War, The Townscape of, by Phillip H. Bacon 238
Nassau, The Growth of, by Cyrus J. Sharer 272
New Zealand Railways, Distribution of Passenger Traffic on, by William H. Wallace 279
Nuclear Power in Europe's Future Energy Supply, The Role of, by George W. Hoffman 252
OLMSTEAD, CLARENCE W., The Role of Lake Michigan in the Orchard and Vineyard Fruit Industry 267
ORVIG, SVENN, The McGill University-Arctic Institute Carnegie Arctic Program 267
PARSONS, JAMES J., The Green Turtle (*Chelonia* spp.): A Diminishing Food Resource of Tropical Seas 268
PATTON, CLYDE P., A Quantitative Assessment of the Thornthwaite Classification of 1948 268

PATTON, DONALD J., The External Port Relations of Halifax and St. John 269
Philippine Interisland Shipping and Trade, by Frederick L. Wernstedt 280
Philippine Sugar Industry: Foundations and Prospects, The, by Alden Cutshall 242
Plant Migrations and General Biogeographic Theory, Recent, by Jonathan D. Sauer 271
Population Distribution in a Semiarid East African Area, The Study of Indigenous, by Walter W. Deshler 243
Portugal, Agricultural Terraces in, by Dan Stanislawski 273
Portugal's Fishing Industry, Some Significant Aspects of, by Richard J. Houk 253
Puerto Rico, Aspects of Industrial Genesis in an Underdeveloped Area: Post-War Development in, by John P. Augelli 238
QUAM, LOUIS O., The Arctic Research Program of the Office of Naval Research 269
Reclamation and Utilization of an Apparent Wasteland, by Berl Golomb 248
Regional Description Based on Texture and Pattern of Unit Areas, by Lester E. Klimm ... 256
Regional Studies, Use of a "Control Area" to Test Hypotheses in Broader, by Andrew H. Clark 241
Regions, Using Significance Tests to Organize Economic, by Leonard Zobler 284
Religions, Some Comments on a Geography of, by Eric Fischer 246
Research in Geography, Team, by Richard J. Russell 271
Resource Development: Illustrations from New England, Non-Geographic Factors in, by Albert S. Carlson 240
Rice in Sierra Leone, West Africa, Dynamics of the Geography of, by Hibberd V. B. Kline, Jr. 256
ROBINSON, ARTHUR H., A Method for Expressing Quantitatively the Correspondence of Mapped Distributions 270
ROEPKE, HOWARD G., Changing Sources of United States Mineral Supplies 271
RUSSELL, RICHARD J., Team Research in Geography 271
SAUER, JONATHAN D., Recent Plant Migrations and General Biogeographic Theory .. 271
SHARER, CYRUS J., The Growth of Nassau 272
SPARKS, ROBERT M., An Analysis of Locational Changes in the Broad Woven Fabrics and Narrow Fabrics Industries between 1945 and 1955 in Pennsylvania Counties of the Philadelphia Standard Metropolitan Area 272
STANISLAWSKI, DAN, Agricultural Terraces in Portugal 273
Statistical Procedures in Geographic Analysis, Use of Certain, by Harold H. McCarty 263
STERN, PETER M., The Impact of Bauxite Operations on Jamaica, B.W.I. 273
STEVENS, RAYFRED L., The Mexico City Picnic Area: A Study in Recreational Geography 274
St. Lawrence Seaway on the Chesapeake and Ohio Railway, The Effects of the, by Wilbur Zelinsky 284
St. Lawrence Seaway on the Economy of Cleveland (Ohio), The Impact of the, by Alexander Melamid 264
STRAHLER, ARTHUR N., Basic Principles of Quantitative Geomorphology 275
Syracuse, New York, Twenty Years of Change in a Portion of the Rural Urban Fringe of, by Eleanor E. Hanlon 249
THOMAN, RICHARD S., A Foreign-Trade Zone (Free Port) on the Great Lakes-St. Lawrence Seaway? 275
THOMAS, BENJAMIN E., The American Concept of Deserts and Oases 276
THOMAS, WILLIAM L., Jr., Notes on the Concept of Culture 276
THOMPSON, JOHN H., Urban Agriculture in Southern Japan 277
THOMPSON, JOHN L., A Case Study of Interregional Labor Migration 277
Thornthwaite Classification of 1948, A Quantitative Assessment of the, by Clyde P. Patton . 268
THORNTHWAITE, C. WARREN, The Climatological Atlas Project of the World Meteorological Organization 278
Tornado Deaths in the United States, Areal Distribution of, by Urban J. Linehan 259

Transportation in Northern Canada, The Development of, by C. H. Herbert 250
Turtle (*Chelonia* spp.): A Diminishing Food Resource of Tropical Seas, The Green, by James J. Parsons 268
TYSON, MAZIE O., The Danish-American Virgin Islands: The Changing Economy 278
Urban Medical Geography, An Exploratory Study in, by Malcolm A. Murray 265
Vegetation, Criteria for a Regional Description and Interpretation of, Pierre Dansereau 243
Vegetation Maps in Geographical Research, by A. W. Küchler 258
Vegetation of a Desert Island, Effects of a Pastoral Economy upon the, by Charles S. Alexander 237
VISHER, STEPHEN S., Changing Significance of Environmental Influences at Bloomington, Indiana 279
WALLACE, WILLIAM H., Distribution of Passenger Traffic on New Zealand Railways . 279
WARMAN, HENRY J., Significant Tempero-Spatial Elements of Human and Cultural Geography 280
Weather Program, Recent Developments in the North Atlantic Ocean, by Paul C. Dalrymple 242
WERNSTEDT, FREDERICK L., Philippine Interisland Shipping and Trade 280
Wheat: A Struggle for an Essential Food in the USSR, Durum, by W. A. Douglas Jackson 254
WITHINGTON, WILLIAM A., Suburban Migration: A Case Study of Winchester, Massachusetts, 1930 to 1950 281
Winchester, Massachusetts, 1930 to 1950, Suburban Migration: A Case Study of, by William A. Withington 281
WOLF, LAURENCE GRAMBOW, Mineral Production and Contemporary Geopolitical Patterns 281
WONDERS, WILLIAM C., Repercussions of War and Oil on Edmonton, Alberta 282
WOOD, WALTER F., Increasing the Value of Small-Scale Maps for Landform Study by the Use of Statistical Inference 282
ZELINSKY, WILBUR, A Method for Measuring Change in the Relative Distribution of Manufacturing Activity 283
ZELINSKY, WILBUR, The Effects of the St. Lawrence Seaway on the Chesapeake and Ohio Railway 284
ZOBLER, LEONARD, Using Significance Tests to Crganize Economic Regions 284

Book Reviews

CRESSEY, GEORGE B., *Land of the 500 Million;* SHABAD, THEODORE, *China's Changing Map, A Political and Economic Geography of the Chinese People's Republic;* ROSTOW, W. W., *et al., The Prospects for Communist China;* WU, YUAN-LI, *An Economic Survey of Communist China;* WALKER, RICHARD L., *China Under Communism, The First Five Years;* THOMAS, S. B., *Government and Administration in Communist China,* rev. by J. E. Spencer 417
LAZARSFELD, PAUL F., and MORRIS ROSENBERG, eds., *The Language of Social Research: A Reader in the Methodology of Social Research, rev.* by William L Garrison 367
PLATT, RAYE E., ed., *Finland and Its Geography,* rev. by Eugene Van Cleef 285
VISHER, STEPHEN SARGENT, *Climatic Atlas of the United States,* rev. by Wesley Calef 365
WOYTINSKY, W. S. and E. S., *World Population and Production: Trends and Outlook* and *World Commerce and Governments: Trends and Outlook,* rev. by Wilbur Zelinsky . 365

ANNALS of the
Association of American Geographers

Volume XLVI MARCH, 1956 Number 1

SOUTHERN RHODESIA—AN AFRICAN COMPAGE*

DERWENT WHITTLESEY
Harvard Universtiy

INNUMERABLE studies of regions underlie the promulgation of theory and practice in investigating and presenting geographic regions which constitutes Chapter Two of a book recently sponsored by the Association of American Geographers.[1] The viewpoint there set forth invites exemplification in all the aspects of regional study made by geographers, but its challenge is particularly compelling in its proposal concerning the compage. This is the most comprehensive kind of region geographers undertake to portray—nothing less than "the entire content of the human occupance of area."

OBJECTIVE AND CRITERIA

In accepting the challenge, a long-standing interest in the regional geography of Africa has fixed upon a portion of that continent for a test case at the level of a province in a four-fold hierarchy of compages: realm, province, district, and locality. The core, boundaries, and coherence of the compage are selected by applying appropriate criteria to the factual characteristics of the area within which the region lies.

The criteria serving as guide lines for the investigation are drawn from two sources—regional geography in general and distinctive themes of African geography. They are here set down in the form of questions, to be answered as the presentation unfolds, although not in the same order.

1. To what extent is the presumptive compage, or at least its core, different from its next neighbors?
   a. What sorts of differentiation appear in the natural environment?
   b. Was there differentiation in land uses by Africans before the present stage of occupance?
   c. Is there differentiation in current land uses by the African and European population, jointly and as separate communities?
   d. Are the differences being intensified or weakened?

* Presidential address, given by the first Honorary President of the Association of American Geographers at its 51st annual meeting, Memphis, Tennessee, April 13, 1955.

[1] *American Geography: Inventory and Prospect*, ed. by P. E. James and C. F. Jones (Syracuse, N. Y.: Syracuse University Press, 1954), pp. 19–68, esp. 32–36, 44–51.

2. In what ways is the compage similar to each of its neighbors—on the south, east, north, and west?
   a. Are the similarities increasing or lessening?
3. The boundary: where does it lie with reference to natural and societal distributions?
   a. What is its character as a line and as a zone?
   b. Does it sharpen differences or favor cooperative administration?
4. To what extent does water condition human life and give it regional distinctiveness?
   a. What paramount uses does water serve and what control measures are desirable and possible?
   b. How does it affect natural vegetation and animal life, and crops and livestock?
   c. What patterns of human occupance are associated with variation in water, including relicts from the pre-European stage of occupance?
5. To what extent do minerals condition human life and lay down a pattern of occupance, again including relicts of pre-European extraction and use of minerals?
6. What changes in the sequence of occupance are occurring or may be in prospect?
   a. Altered political affiliations?
   b. Outside contacts?

Using the criteria to test distributions within the block of territory formed by the Zambezi and Limpopo river basins (Fig. 1) brings into sharp focus an area between the streams as a nodal compage at the level of a province. It approximates the political region of Southern Rhodesia and is authentically a unit, possessing a regional core distinctive in itself and set off from neighboring compages by well-marked border zones. At the same time it is clearly transitional between the Union of South Africa to the south and Northern Rhodesia and Nyasaland to the north, standing between them not merely in location, but also in aspects of geography, both natural and societal, that stamp those segments of earth-space as separate compages. Its status is likewise intermediate within the current period of occupance, which began earlier to the south and later to the north, but in some degree runs parallel in all three areas.

SALIENT REGIONAL VARIETY

The political unit of Southern Rhodesia covers 150,333 square miles. In 1951 the population was officially set at 2,106,300 (Fig. 2), divided among four communities: by census count, 136,000 Europeans, 4,340 Asians, 5,960 colored (i.e., racial mixtures), and an estimated 1,960,000 Africans.

The distribution of this population, while averaging just over seven per square

mile, is uneven, corresponding in some measure to available water in a land where rainfall is rather low, as indicated by the following tabulation:[2]

Inches per annum	*Percentage of area*
More than 35	9
30–35	20
25–30	42
20–25	20
Less than 20	9

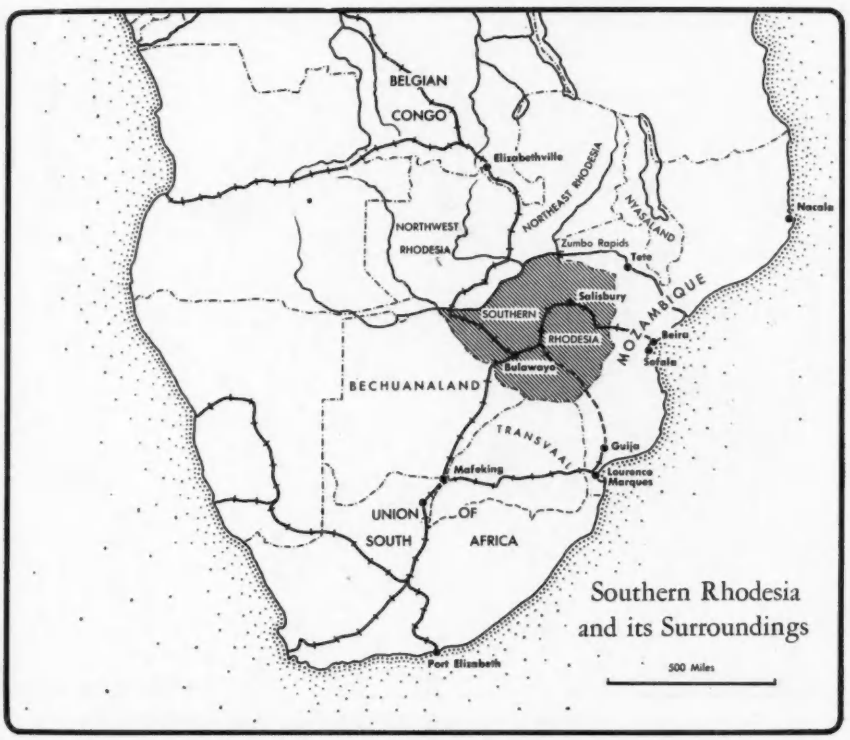


FIG. 1. Southern Rhodesia and its surroundings.

The standard deviation from the mean for the whole country is seven inches, but actual precipitation is notably more variable and unreliable than that figure suggests, except in the mountains along the eastern border—the only area receiving more than 35 inches on the average. Downpours like one experienced long ago by an early visitor still occur:

[2] Adapted from *The Climate of Southern Rhodesia,* unpaged government pamphlet, n.d. (*ca.* 1950).

> . . . rain was beginning to fall in heavy drops. . . . In a very few minutes it was quite impossible to see anything of the waggon track, except by the lurid glare of the frequent flashes of lightning. . . . And now the rain came down solid, in such a way that, although the soil under foot was deep loose sand, the lightning showed a sheet of water, for the sand could not absorb the rain as fast as it fell.[3]

Four- and five-inch falls have been recorded in different places. Such excess may occur in seasons of total shortage, and drouth is recurrent. The rainy season of

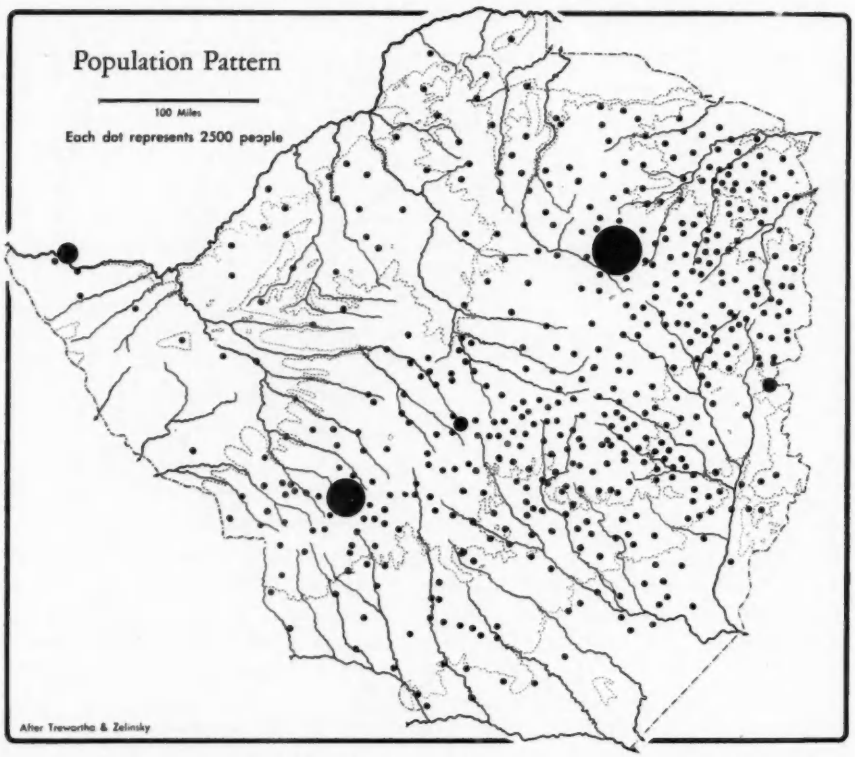


FIG. 2. Population, *ca.* 1950. The base delineates the three critical altitudes—Low, Middle, and High Veld. After Trewartha and Zelinsky in *Annals,* Association of American Geographers, Vol. 44 (1954), pp. 140 and 144.

1951–52 was the heaviest in eleven years, during several of which the country had suffered from insufficient rain. Many reservoirs built during the preceding five years had never been filled before. In 1954 crops were damaged by flooding of fields.

Besides a wide range over the years, the rainfall average varies notably from

[3] Frederick C. Selous, *Travel and Adventure in South-East Africa* (London, 1893), p. 152.

place to place (Fig. 3). Lands below 2000 feet lie in troughlike valleys or in the rain-shadow of mountains and receive less than most of the uplands. Evaporation is rapid on the lowlands, since the mean annual temperature ranges from 70° to 80° F. On the uplands, average annual rainfall diminishes from 52 dependable inches in the northeast to an unpredictable amount averaging 21 inches in the southwest.

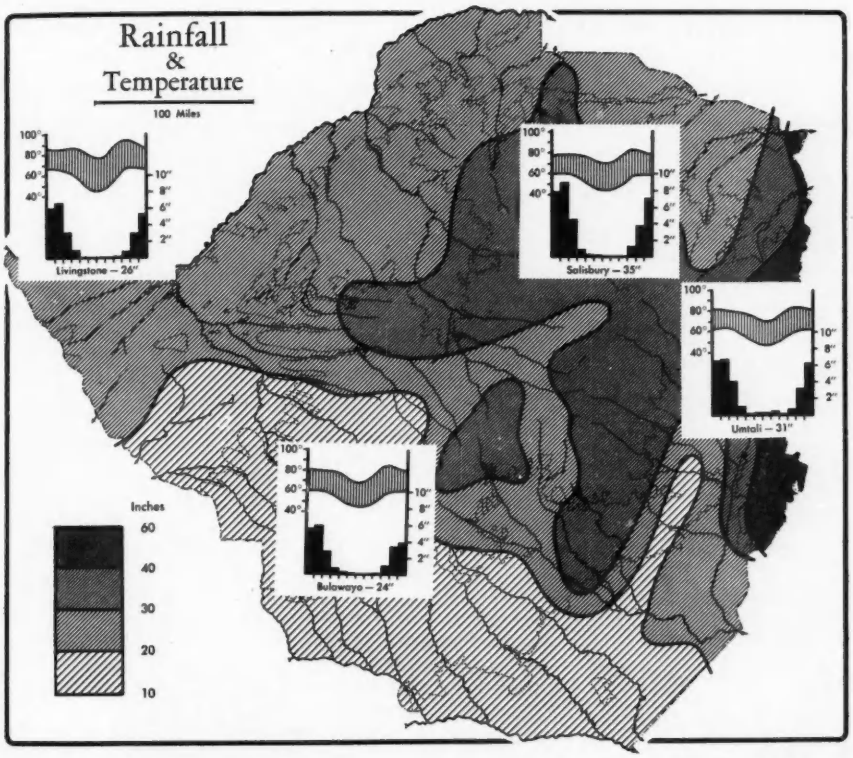


FIG. 3. Average annual rainfall and temperature, superimposed on the three critical altitudes. The graphs represent climatic conditions in different parts of the country. Rainfall is presented by months from January to December. The range between average maximum and average minimum temperatures is indicated by shading.

Correlation between population and rainfall is less striking than correspondence between population and altitude. Temperature decreases with altitude, which varies from little-used lowlands to lands high enough to favor domestic animals and a considerable range of crops, and to induce widespread occupance by both Africans and Europeans.

In Southern Rhodesia the mean annual temperature between intervals of 1000 feet of elevation runs as follows:[4]

Altitude	*Percentage of area of Southern Rhodesia*	*Mean annual temperature range, °F.*
Below 1,000 feet	1.3	82–76
1,000–2,000 feet	14.4	80–74
2,000–3,000 feet	19.6	77–70
3,000–4,000 feet	40.5	72–65
4,000–5,000 feet	21.5	68–63
Above 5,000 feet	2.7	65–60

So critical are certain levels that the country is locally recognized as being divided

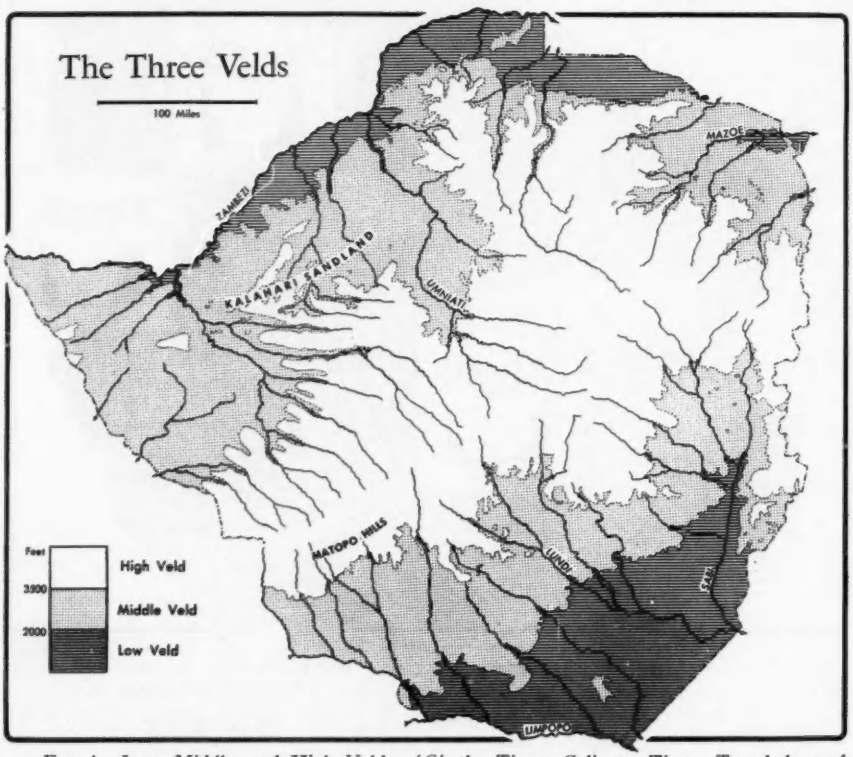


FIG. 4. Low, Middle, and High Veld. (*Cf.* the Tierra Caliente, Tierra Templada, and Tierra Fria of low-altitude America.)

into Low Veld (below 2,000 feet), Middle Veld (2,000–3,500 feet), and High Veld (above 3,500 feet) (Fig. 4). The three zones are differentiated by an associated variation in the natural environment compounded chiefly of the following elements:

[4] *The Climate of Southern Rhodesia, op. cit.*

animal life ranging from big game to non-filterable viruses, vegetation, terrain, temperature, and surface and ground water.

THE LOW VELD (UP TO 2,000 FEET)

Nearly the entire northern and southern boundaries of Southern Rhodesia have been drawn along rivers. In flood the rivers cannot be forded, and the Zambezi has cut deep gorges where it has uncovered blocks of crystalline rock between Tete in Mozambique and the Victoria Falls. The famous cataract is actively lengthening the uppermost of these gorges.

FIG. 5. Mopane bush surrounding a newly established village in the Low Veld.

The boundary streams flow in structural troughs of rocks that are dominantly sediments and lavas, and everywhere the margins of these troughs are marked by higher, rugged terrain. On the soft rocks of the troughs the relief is gentle, with low tabular hills the only features. The terrain is given a monotonous appearance by being covered with an almost pure stand of mopane (*Capaifera* sp.), an indicator of ill-drained, refractory soil regardless of origin. The natural landscape has been altered by human endeavor in only a few spots (Fig. 5). As in most low-latitude lowlands of Africa, a number of diseases attacking both human beings and their livestock are endemic, although the nature of their spread was not learned until after Europeans had taken over the country.

The Zambezi Trough is rather narrow, very steep sided and deep, and so dry that it supports only a sparse population of Africans, and scarcely any Europeans,

most of them missionaries. The Limpopo Trough is broader and the ascent to the high ground is less precipitous. To the east it widens northward along the Sabi River system, forming the only large expanse of Low Veld in the country. The extreme southeast is uninhabited; there a gravelly region has been set aside as a game reserve (Fig. 6) contiguous to similar reserves in both Mozambique and Transvaal. Farther north, and 500 to 1,000 feet higher, there are settlements that

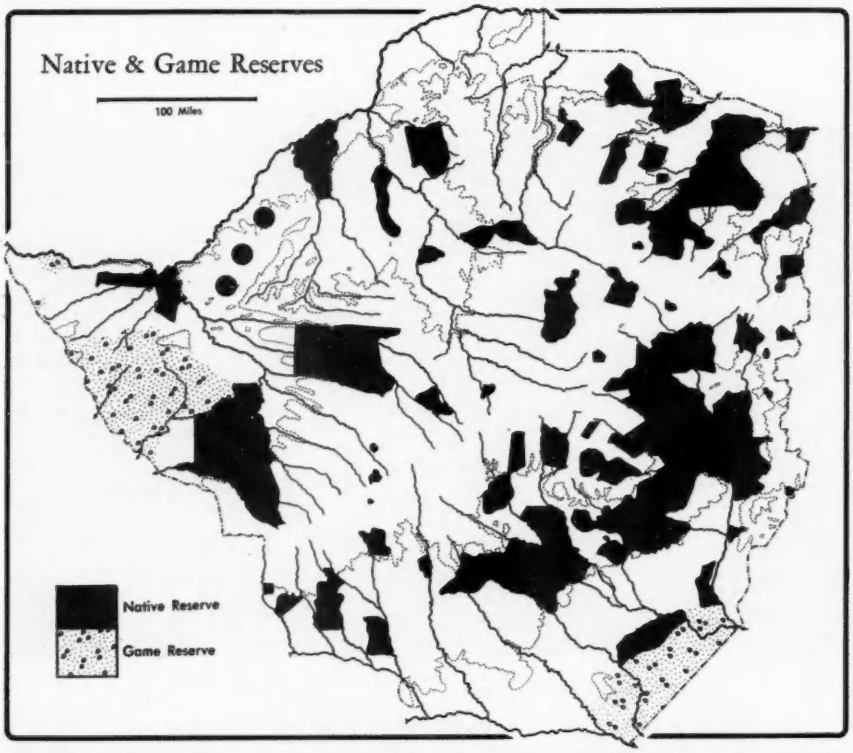


FIG. 6. Lands occupied by and reserved to Africans, and areas set aside as game preserves.

make the Basin of the Sabi the most populous part of the Rhodesian Low Veld. It is a dry district, because it lies in the rain shadow of the mountain ranges that border Southern Rhodesia on the east side—*i.e.*, toward the oceanic source of moisture. Nevertheless some crops are grown with the rains, and potential crop and grass lands have been reserved for the inhabitants. During the past decade or so the population has grown rapidly, thanks to half a dozen irrigation projects. The farmers are Africans, and they get yields of grains three to four times the country's average. They also grow several tropical fruits which find a ready market on the highland.

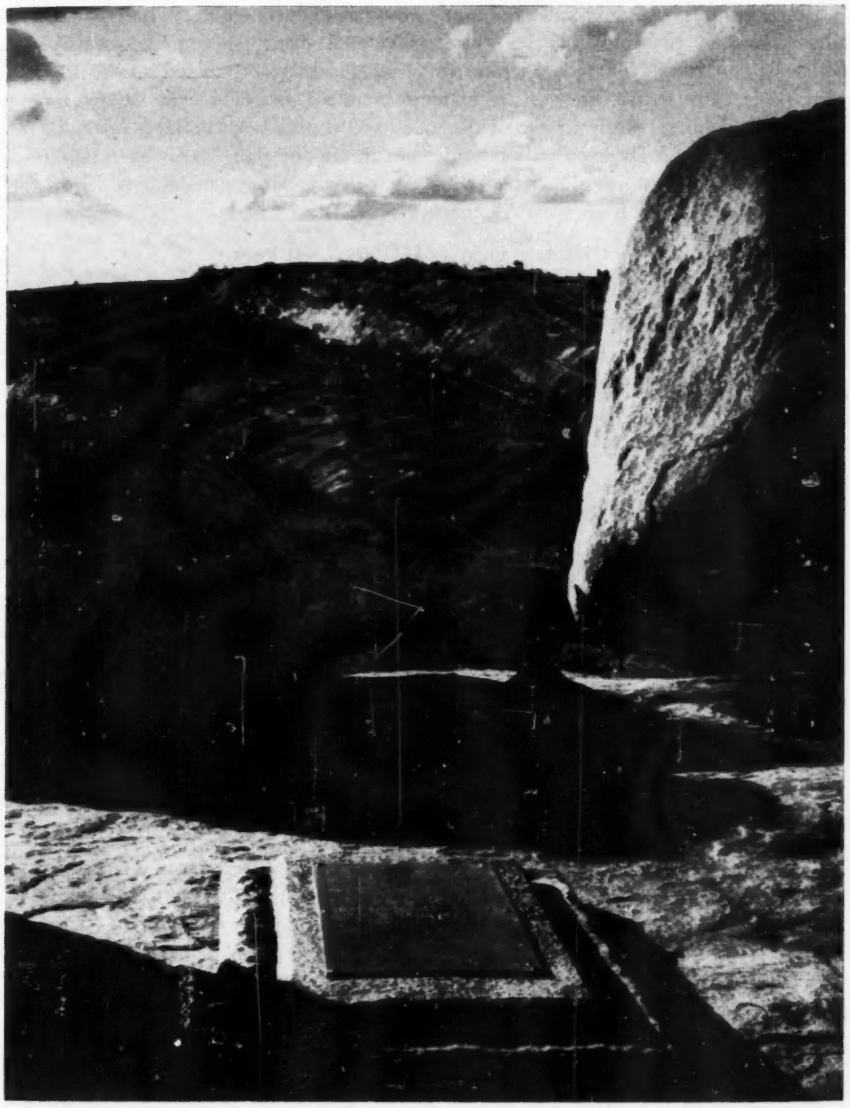


FIG. 7. Bedrock, boulders, and caves dominate dissected granitic uplands, as here in the Matopo Hills. Brush finds scattered footholds in clefts and on talus at the foot of slopes. The slab in the foreground marks the grave of Cecil Rhodes. *Courtesy of the Southern Rhodesian Government.*

European occupance is scattered and somewhat experimental. The government aids sugar-cane planting, but the output of refined sugar does not yet satisfy the Rhodesian market. There are cattle ranches, generally organized as stock companies. Serious cattle diseases are endemic in the Low Veld, and have retarded livestock ranching. Only in recent decades have causes been understood and preventives found. A large irrigation project in the upper Sabi Basin has made possible a European farming district in which dairying is prominent, but it lies in the Middle Veld, not far from Fort Victoria, a High Veld town.

THE MIDDLE VELD (2,000 TO 3,500 FEET)

Low Veld gives way to the Middle Veld at about 2,000 feet (Fig. 4). This level is taken as the approximate dividing line, not because of the altitude, which

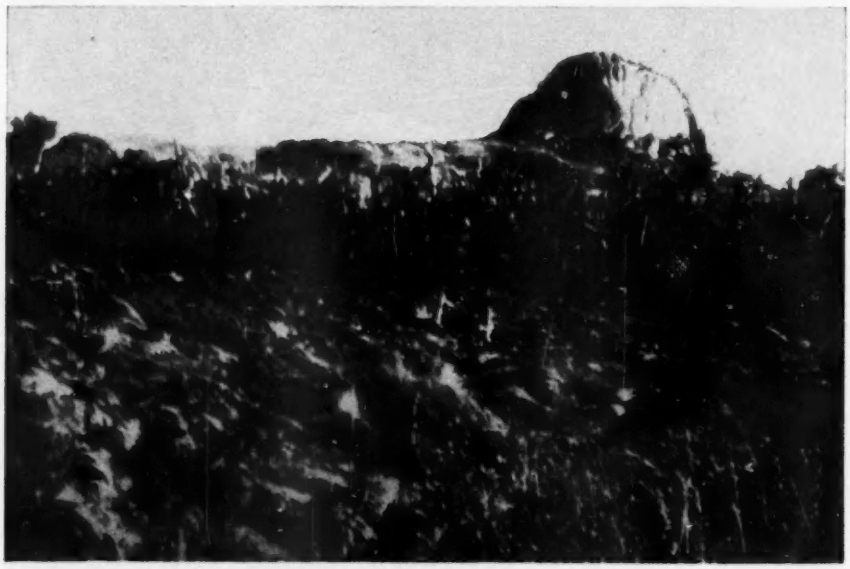


FIG. 8. A bare island hill (also called *sugarloaf*, *inselberg*, and *bornhardt*) partly buried in talus. The foreground is a bog kept moist by seepage from the higher ground. It is freshly plowed, preparatory to planting.

modifies the climate little, if at all, but because above it the terrain rises steeply and except on the northwest is deeply dissected and presents extravagant displays of the landscape of domes, crags, boulders, and caves typically produced by weathering of granite surfaces in tropical climates (Fig. 7). Numerous crests thus formed are bare protuberances, perhaps rising out of rock debris ranging from huge boulders to coarse sand. The most striking are sugarloaf mountains—each one a dome standing well above the girdle of weathered rocks that have chipped off and slid down its steep, smooth slopes (Fig. 8). Being isolated, these conspicuous features

of the terrain are often called island hills (*inselberge*). Less symmetrical but commoner are castle hills—masses of rock that have cliffed sides and flat tops of unequal height, and that usually stand in groups (Fig. 9). Cubic or rounded rocks may become detached and lie in a tumble of huge boulders. Numerous caves are associated with these irregular rocky crags.[5]

The myriad bare crests are presumed to be remnants of a former peneplain. They are most numerous in belts 50 to 100 miles wide that have been sharply dissected by stream erosion to create local relief up to 1,500 feet. These rock-forms are found in the northeast among tributaries of the Zambezi, and especially in the

FIG. 9. A castle hill made up of massive granite bedrock exposures and fissured cliffs, with a scattering of brush and low trees. Many castle hills are smaller than this one, and culminate in a single group of cliff-sided rocks, admirably suited as a defense point.

south, up-slope from the Limpopo Trough. They are most spectacular in the Matopo Hills of the southwest. This jumble of island hills, castle hills, boulder fields, and caves, some 1,200 square miles in area, lies at the level of the High Veld and shares the comforts and rigors of climate at 4,000–5,000 feet. But its rugged surface, located between the rolling High Veld and the flattish Low Veld, places the Matopos as part of the Middle Veld. It is such an extreme expression of rugged

[5] Masses of dissolved minerals that are intruded into the earth's crust cool slowly, causing joints to form as they solidify into granite rock. When weathering and erosion have uncovered the granite and it is in turn exposed to weathering, the joints provide lines of attack: marked changes in temperature from day to night slough off thin shells of rock; growing plant roots widen cracks; acids from decaying vegetation disintegrate the crystalline structure. See Lester King, "A Theory of Bornhardt's," *Geographical Journal*, Vol. 112 (1949), pp. 83–87.

grandeur that Cecil Rhodes chose it as his burial place (Fig. 7), and others "who have deserved well of their country" are likewise interred in this rocky Valhalla.

Whether standing singly or in groups, the castle hills and boulder-strewn heights have traditionally been used as defense points to defy aggressive enemies. Drawings, bones, and artifacts prove that the caves have for centuries served as refuges for small groups whose weakness compelled them to hide. The steep, smooth island hills have military value as observation posts and for cover in open skirmishing.

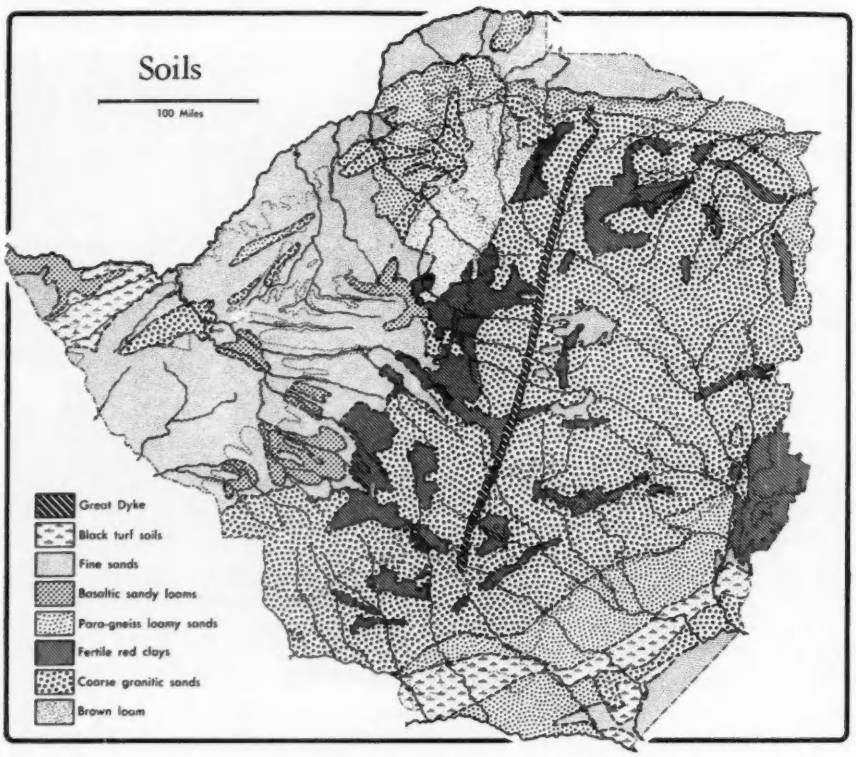


FIG. 10. Principal soils regions.

Eastward the Middle Veld decreases in altitude and narrows to form the broken rim of the Sabi River system.

In the northeast (between 22° and 35° E.) a faulted zone descends more than 2,000 feet, from High to Low Veld, within two or three miles. This is the most conspicuous part of the Zambezi Escarpment, and both to the west and to the east tributary streams have cut back into it one or two score miles to form ribbons of Middle Veld, with its characteristic rocky eminences.

In the northwest, to and beyond the western tip of the country, the dissection by Zambezi tributaries fades into a broad, level plain of red loess (limon) known as the Kalahari Sand (Fig. 10). It appears to have been deposited by wind during a period of scantier rainfall than now. It has buried inequalities of the earlier surface, and varies in thickness from 10 to 200 feet. The few streams flow so sluggishly across this mantle that their direction can hardly be detected. Some lines of waterfilled depressions, locally called pans, indicate seepage along sand-filled drain-

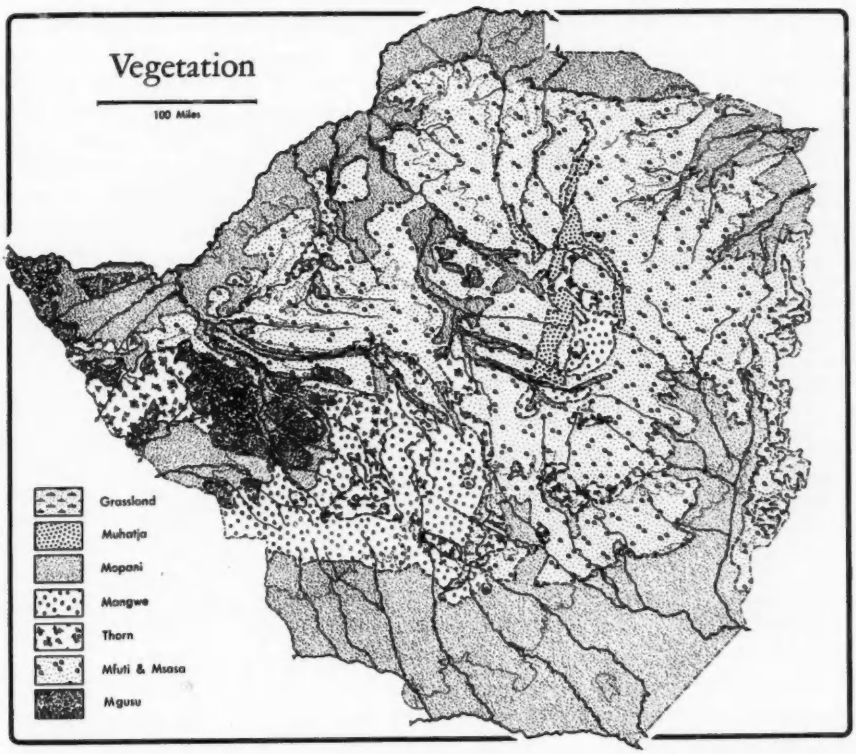


FIG. 11. Natural vegetation regions, showing dominant combinations of plant cover.

ways. Over large expanses there is no surface water, and in places very little below ground. The railway has to haul water for its locomotives on part of its line.

Being of desert origin, the soil is fertile, and it receives 20 inches of rain a year along the western Rhodesian boundary and nearly 40 inches on the eastern margin of the Sand. But the rainfall is unreliable, straying 20 to 25 percent from the mean. Moreover, true Kalahari Sand absorbs little rainwater except within a few feet of the surface, where the fine and compact loess texture has been disturbed by roots,

burrowing insects and animals, wind, or fires. Many spots are waterlogged during the rains, forming grassy, treeless bogs. Where runoff is faster, small bush with savanna is the rule (Fig. 11). The commonest is mopane (*Copaifera* sp.) woodland, but some areas are dominated by mgusu (*Baikiaea* sp.), msasa (*Brachystegia* sp.), or thorn (*Acacia* spp.). Considerable stretches are open enough to permit long views. The largest game reserve in the country occupies a good deal of the western borderland (Fig. 6).

The flatness of this area is indicated by the undeviating straightness of the railway for the phenomenal distance of 72 miles. The surface of the sandland is totally at variance with the rest of the Middle Veld. It is considered to be Middle Veld because high temperature below 3,500 feet, rainfall insufficient to keep the surface sand moist, and a water table far below the surface have combined to make crop production and cattle-ranching precarious undertakings. European settlement has hardly invaded it, although there are Native Reserves of large size but small population. The administrative unit that includes the sandland is the least populous in Southern Rhodesia, even though it includes coal-mining and resort settlements in the extreme northwest.

In Bechuanaland, beyond the western border of Rhodesia, the Kalahari Sand becomes more widely spread to form the so-called Kalahari Desert. On both sides of the boundary it is separated from the Middle and Low Veld to the southeast by a neck of higher land that forms the watershed between Zambezi and Limpopo drainage.

THE HIGH VELD (ABOVE 3,500 FEET)

The plateau between the Zambezi and Limpopo watersheds broadens northeastward and spreads across Southern Rhodesia to form the core of the compage—the High Veld (Fig. 4).

Occupance Before the 19th Century

No historical records exist to describe settlements in the region earlier than the mid-19th century, but archeological evidence proves a long and presumably continuous occupance, including bordering portions of the Middle Veld.

First in time are cave paintings that were the work of Bushmen. Successive waves of Bantu from the north are believed to have driven the Bushmen westward into the Kalahari Desert.

At some subsequent period structures of dry masonry, exhibiting fine craftsmanship and variety of design, were erected, usually on or among granite exposures (Fig. 12). There are some 200 deserted ruins of such structures, many of them small, but some covering many acres. Half of them have been surveyed. These figures take no account of similar stone walls protecting villages that were occupied when first visited by Europeans. The generic name for the earlier structures is *zimbabwe*, and they are believed to have been fortresses, with some of their buildings devoted to religious rites. All are among hills, nearly always castle hills and associated boulder-strewn fastnesses. Half a dozen of the largest make a unique tourist

attraction.[6] In the Inyanga district of the northeast whole hillsides are notched into terraces four to six feet wide, supported by masonry walls two to four feet high and associated with canals which may have been used to irrigate them. Thereabouts, pits of unknown use are numerous.

The most reliable authorities hold that all these works were built by Bantu (because all skeletons found among them are negroid), and not earlier than 900 A.D. Construction may have been associated with gold mining.

FIG. 12. Walls without mortar erected on a castle hill, the highest point of which is at the upper right. A part of the Great Zimbabwe. *Courtesy of the Southern Rhodesian Government.*

Gold was dug all over the High Veld, as attested by many ancient workings that had removed ore as far down as the permanent water table, which the miners were unable to cope with. The treasure appears to have been exported from the continent, perhaps by way of Sofala, a port today reached only by shallow-draft dhows, but active in both Arab and Portuguese trade of earlier centuries (Fig. 1).

[6] Matendere, halfway between Umtali and Fort Victoria; the Great Zimbabwe, 17 miles southeast of Fort Victoria; Dhlo-Dhlo, about 15 miles south of Shangani Railway Station; Khami, the same distance west of Bulawayo; several close together near the lower Lundi River. A number of others are also named on the topographic map, scale 1 : 500,000, published by the government of Southern Rhodesia.

It seems likely that the art of masonry deteriorated until a village currently occupied in 1890 could be described as "undefended by anything but a small fence," whereas an earlier settlement of the same tribe, though in ruins, was still imposing:

> . . . there was a hill on which were built several concentric walls and the stone foundations of round huts, the whole being surrounded by a moat. A little farther on there was a small kopje [hillock] composed of a few large blocks of granite, some of which were piled up in the centre in the form of a tower. The whole of this kopje was enclosed by a very well-built wall about two hundred yards in circumference, eight feet in thickness, and ten feet in height. . . . Through this wall there were four entrances, apertures about four feet in height and two and a half feet in breadth. These apertures were let into the base of the wall, and were roofed over with large flat slabs of granite. Inside this wall were the foundations of numerous round buildings. These foundations were all very well built of closely-fitted pieces of square granite, and were about eighteen inches in depth. The huts that were built upon them must have been at least four times the size of the huts used by the natives at the present day. . . . About half a mile from this old walled town was the burial-place, . . . one side of which was enclosed by a beautifully-built wall about ten feet high, of evenly-laid and squared granite stones, most carefully fitted together without mortar. . . . This place is . . . spoken of [by the local people] as "The Zimbabwi." Here in time of national trouble the chief slaughters cattle, and makes propitiatory offerings. . . .[7]

The same observer also gives a picture of an occupied defense point:

> [The] hill is one of many very remarkable rocks about here, immense blocks of stone rising sheer from the level plain to a height of several hundred feet. The huts and storehouses for rice and corn were built on the very summit of this huge rock, which must be altogether impregnable . . . as on the one side it is a . . . precipice . . . and on the other can only be scaled by its inhabitants in certain places. . . . A fine spring, welling out of the rich black soil, poured its waters into a clear stream that flowed past the foot of [the] hill.[8]

He contrasts it with what he believes to have been the character of occupance at the beginning of the 19th century, when the villagers dared to dwell on the open veld:

> This fine country must have been thickly inhabited, as almost every valley has . . . been under cultivation. The sites of villages are also very numerous, though now only marked by a few deep pits from which the natives obtained the clay used by them for plastering their huts and making their cooking-pots, and also the presence usually of a cluster of huge acacia-trees, which grow to a far greater size on the sites of villages than anywhere else. On the summit of every hill may be found the wall, in more or less perfect preservation, of what, I think, must have been cattle kraals. These walls are very neatly built. . . . The peaceful people inhabiting this part of Africa must then have been in the zenith of their prosperity. Herds of their small but beautiful cattle lowed in every valley, and their rich and fertile country doubtless afforded them an abundance of vegetable food. . . . Zulus, under their warlike chiefs . . . very soon . . . overran the peaceful vales of the Mashuna country in every direction. The poor Mashunas, unskilled in war, and living, moreover, in small communities scattered all over the country, without any central government, fell an easy prey. . . . Their cattle, sheep, and goats were driven off by their conquerors, and their children, when old enough to walk were, of course, killed together with their mothers. In a very few years there were no more Mashunas left in the open country, the remnant . . . having fled into the mountainous districts. . . .[9]

[7] Selous, *op. cit.*, pp. 339–340.
[8] *Ibid.*, pp. 50–51.
[9] *Ibid.*, pp. 80–81.

The inhabitants of the region may have owned larger herds and tilled more soil in the earlier period, but some tribes may always have preferred the safety of castle hills for their villages. The same observer reports:

> . . . beyond the farthest point ever reached by a . . . marauding expedition . . . we found numbers of small native towns, perched upon the hills, . . . a large native population . . . seemed very comfortably off, and were in possession of numbers of cattle and large flocks of goats.[10]

A more specific description gives the same impression:

> [A] village, which held about two hundred people, . . . was built on a level plot of ground, surrounded by kopjes [hillocks] composed of large and small bowlders, among which were

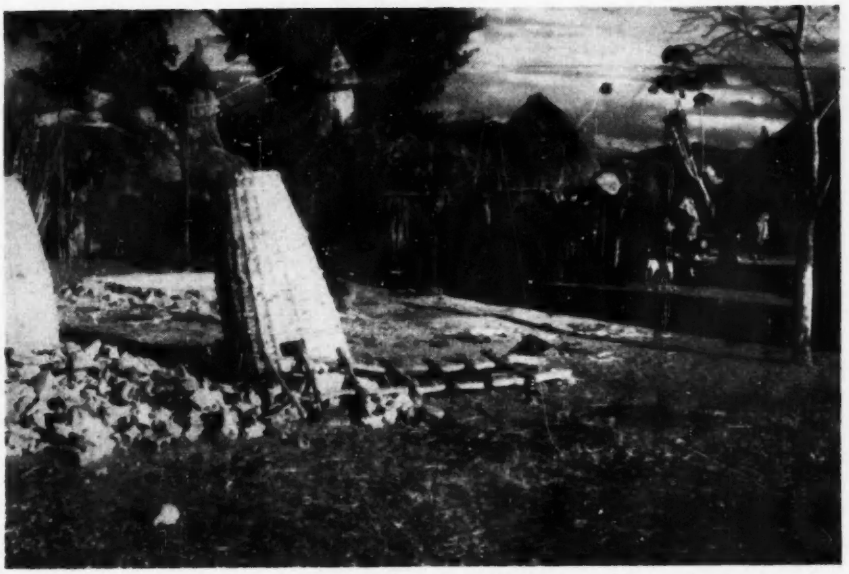


FIG. 13. Huts (right) and granaries (left) erected on smooth but not level granite bedrock. In the foreground are a partly finished grain bin and a ladder for filling bins from the top. The granaries, built about 1950, are taller than those observed in the 1890's, but otherwise fit the description here quoted.

> caves and recesses, partly natural, but supplemented with artificial stone walls, thus making an excellent refuge and fortress in case of attack. On top of the large bowlders, scattered more or less over all these kopjes, were small grain-bins, each about four feet in height by three feet in diameter, built of mud and sticks and covered with a small thatch roof, giving them the appearance from a distance of thick-stemmed toadstools [Fig. 13]. The village, consisting of about fifty huts, was surrounded by a stockade built of upright poles and banked outside with thorn bushes. This served as a barrier to prowling night animals and also answered the purpose in case of attack of checking the enemy long enough to let the people escape into the caves among the rocks.[11]

[10] *Ibid.*, p. 53.

[11] William Harvey Brown, *On the South African Frontier* (New York, 1899), p. 190.

Troubled Times in Mashonaland

Whatever may have been the ease of life at an earlier date, when European missionaries and hunters began to visit Mashonaland (Fig. 14), they found the inhabitants harried by a succession of invading tribes. These tribes themselves had been driven out of their native Zululand by the military leader Chaka, who made himself master in southeastern Africa about 1820. At that time two tribes fled

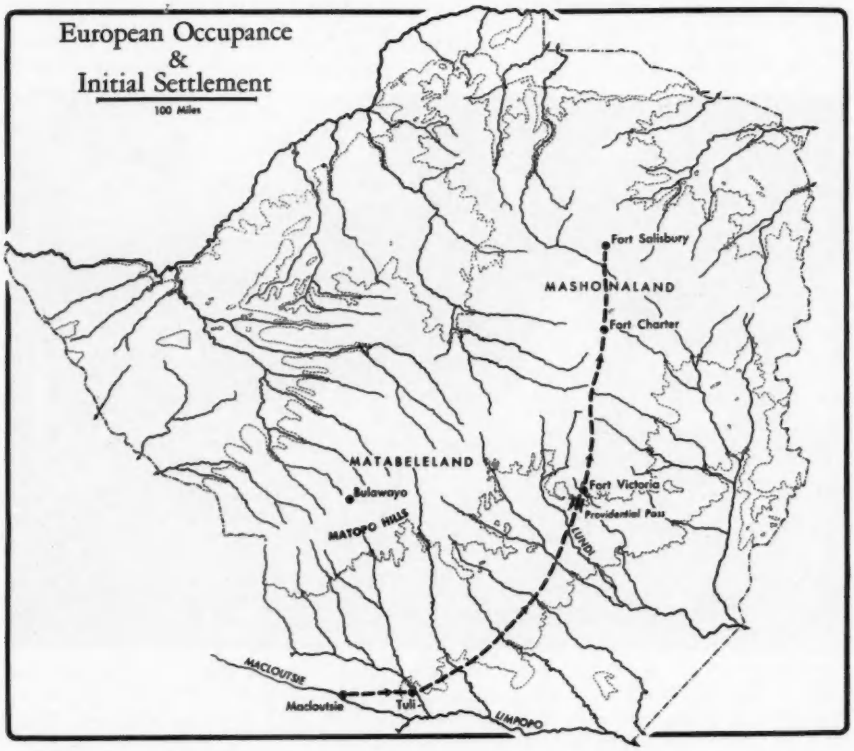


FIG. 14. European penetration and initial settlement.

northward into the upper Sabi Basin, presumably at the expense of earlier settlers. Their own rivalry reached a climax in a three-day battle. The Angoni, defeated, moved north across the High Veld, which they devastated, crossed the Zambezi above the rapids of Zumbo, and forced their way onto the plateau west of Lake Nyasa, where they still live. The Abagaza, victorious, settled the highland immediately east of the Sabi Basin. From that base they continued to raid the adjacent High Veld.

About 1840 another tribe from the south, the Matabele, made their way into

the western High Veld. After a stay on the northern fringe of the protective Matopo Hills, they set up their central camp (kraal) on the open grassland, at a flattopped eminence thenceforth called Thabas Induna (Headman's Hill). Later the chief moved his kraal ten miles west to Bulawayo, a site featuring a great tree beneath which he sat when administering tribal affairs. The Matabele, raiding in all directions in accord with their military tradition, found their best source of cattle, grain, and youths, to replenish their pool of warriors, eastward on the High Veld. The land they themselves occupied was salubrious and fine grazing country, but somewhat dry for raising crops.

FIG. 15. A village on a castle hillock, outlier of a granite range. The pebbles and coarse sand in the foreground constitute the village plowland. In the dry season a scanty growth of weeds yields some forage for the famished cattle.

Raiding turned the pastures and field plots of southwestern Mashonaland into an untenanted boundary zone between Mashonaland and Matabeleland. In the attrition, the harried groups lost their tribal distinctions and came to be known collectively as Mashona, despised by their warlike neighbors.

Character of the High Veld

The High Veld was the region most prized by Africans when the area between Limpopo and Zambezi was first visited by missionaries and hunters. For several decades European immigrants made no serious attempt to settle permanently anywhere else, and that part of the country was and is the core of the geographic province. At 4,000 feet the mean monthly temperature ranges from 57.7° F. dur-

ing the two driest and coldest months, to 70.5° F. during the five hottest months (when the rains fall). Nearly a quarter of the political unit lies above 4,000 feet, and another fifth between 3,500 and 4,000 feet, where temperatures are only a little higher. The daily range is pronounced, especially in the dry season, when light ground frosts are common at night while continuously sunny days are associated with low relative humidity.

The principal climatic variation is the range and reliability of the rainfall (Fig. 3). On the eastern border, 50 inches can be counted upon, because mountain ranges, rising to peaks 7,000 feet above the sea in the south and 8,500 in the north,

FIG. 16. Cattle in nourishing pasture of tall grass. The scattered trees provide shade during the rainy season, but gradually lose their leaves as the dry season advances.

intercept moisture-laden air from the Indian Ocean. The western border averages only two-fifths as much rain, and any area west of the mountains is subject to recurrent drouth. Most of the time the High Veld is breezy, making even the wet, hot months tolerable.

The variety in rainfall appears in the natural vegetation (Fig. 11) although the correspondence is blurred by overlap. Rainfall is decisive in agriculture: in the eastern half crops are the mainstay of both Africans and Europeans, with cattle secondary; the west is livestock country, with little crop-growing, some of that being under irrigation. This is the major regional cleavage within the core of the region, recognized at every stage of occupance.

Except for the eastern mountains, the High Veld is rolling, punctuated by low ranges and by the granitic exposures of island and castle hills, rising above talus

and surrounded by coarse soil of mixed sand and fine gravel (Fig. 15). Such soil is well drained, strongly acid, and buff or pinkish gray. Downslope it may become orange red and deepen to 30 or 40 feet. At the bottom of a slope, it gives way rather abruptly to bogland of black or gray-black, heavy, acid soil that lies waterlogged during the rains and holds enough moisture well into the dry season to provide pasturage for cattle that browse on the tall grasses which grow there to the exclusion of trees.

The light soil weathered from granite bears tree-savanna. Its coarse grasses grow tall during the rains and are suitable for grazing until they turn brown as the

FIG. 17. Preparation of a field in chitamene farming. All saplings and the limbs of larger trees from the clearing shown are heaped for burning. (The scale may be deduced from the cap, a white spot on the nearest brush pile.)

drouth lengthens (Fig. 16). The universal African practice was to burn it, in order to make way for grass that sprouts a week to a month before the rains begin, thus providing forage much needed by the cattle grown thin from the poor pickings elsewhere at that time of year. The clumps and belts of small bush that originally dotted the sandy soils were dominantly msasa (*Brachystegia* sp.) and mnondo (*Isoberlinia* sp.). In places they were so scattered that they permitted fairly long views, but elsewhere thickets obscured all but the immediate surroundings. With crude tools made by native craftsmen from iron found near the surface, the villagers could girdle the trees, lop off the branches, burn the trash, and turn the light soil into farmed patches, in a system of shifting cultivation known as chitimene (Fig. 17).

> The natives make no effort to renew the soil by fertilizing; hence, as this light loam does not produce well for more than three seasons, the men go forward and begin to devastate a new forest by climbing into the trees and cutting off the tops. These are piled around the trunks and, when dry, burned, thus deadening the trees, while at the same time making the earth more fertile with the ashes. The women follow after with their hoes, turn over the ground into narrow furrows, and plant it in mealies. . . .[12]

In pre-European times mealies (maize) took a place alongside millet as a leading staple crop, but the granitic soils yield low returns.

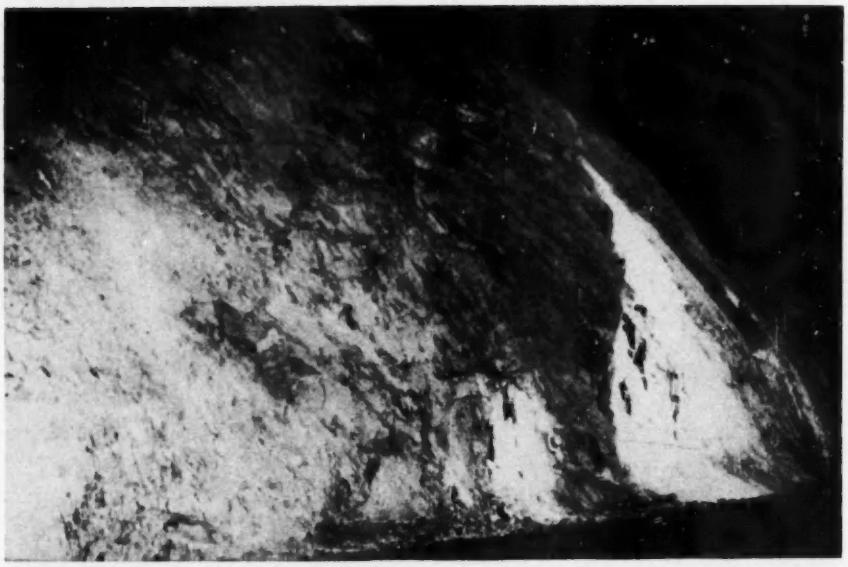


FIG. 18. A recent road cut, exposing soil derived from basic bedrock. The rock structure is clearly visible, but it has disintegrated to a fine texture, and the weathered (darker) surface has turned cocoa color since the cut was made. Beneath the surface the finely divided material is pink, the lighter color shown in the landslides, which were caused by scratching the surface just before the photograph was made. The sun-helmet gives scale.

Throughout the High Veld are innumerable patches of clay soils more fertile than the granitic sands (Fig. 10). They are derived from basic rocks, mainly metamorphosed and commonly interbedded lavas and sediments, and they present considerable variety of parent material and soils. Some of these areas have resisted erosion and stand out as low hills and mountains. Many more are indisdistinguishable as features of the terrain, but their distinctive soils set them apart.

The characteristic soil originating in basic rocks may contain boulders and pebbles at the higher levels, but downslope it becomes fine-grained and deep, generally red, but varying to dark chocolate or, more rarely, to orange (Fig. 18). At the lowest level is bog soil (Fig. 19) looking much like that associated with granite, but more

[12] Brown, *op. cit.*, p. 190.

fertile because slightly alkaline in reaction. Bogs in their natural state are grass-covered. The red soils include numerous grassy expanses, but they generally carry an open scattering of woodland (small bush) above a heavy stand of grass. Thorn (*Acacia* spp.) is the vegetation most closely correlated with the red soils. The boundaries correspond in many places. Less neatly coincident are muhatja (*Parinarium* sp.), and in the north mfuti (*Brachystegia* sp.). In still other places the basic soils bear the msasa-mnondo combination found widely on acid granite soils, and everywhere there is considerable intermixture of species.

FIG. 19. A bog at the foot of a slope. In the bottom of the depression is a pond (right middle distance). Elsewhere beyond the fence is an expanse of grass. The foreground has been plowed and will be planted to vegetables for sale in Salisbury.

Other soils are related to more specialized conditions. Termite hills are not conspicuous on the High Veld, probably because they are low, rounded domes. Where they have been plowed as parts of a field they show blacker soils than the surroundings, and are somewhat more fertile. On some resistant rocks the soil is shallower than elsewhere, poorly drained and black, neutral in reaction and fertile, covered with grass and a few stunted trees. Soils on identical bedrock, if formed on well-drained slopes, are red and bear thick grass and bush, generally mfuti (*Brachystegia* sp.) and associated species. Some areas of fine sand, presumed to be relict patches of Kalahari Sand, bear pure stands of grass. Other grasslands occur on the high mountains along the eastern border and on some ranges farther west.

A sharp soil variation occurs along the Great Dike. This is the most notable geologic feature of the High Veld, which it traverses in a north-south direction, extending 300 miles, with an average width of about three miles. Its principal minerals are norite, pyroxenites associated with nickel and platinum, and serpentines with chromite. The soils are high in magnesium, and produce poor crops of maize. They are shallower than average, and they range in color from brown through gray to black. While distinct as to soils, the Dike emerges as a ridge only in segments that stand 500 to 1,500 feet above the general plateau level. Elsewhere streams cross it at grade, or flow along it, and main highways and railways cross it

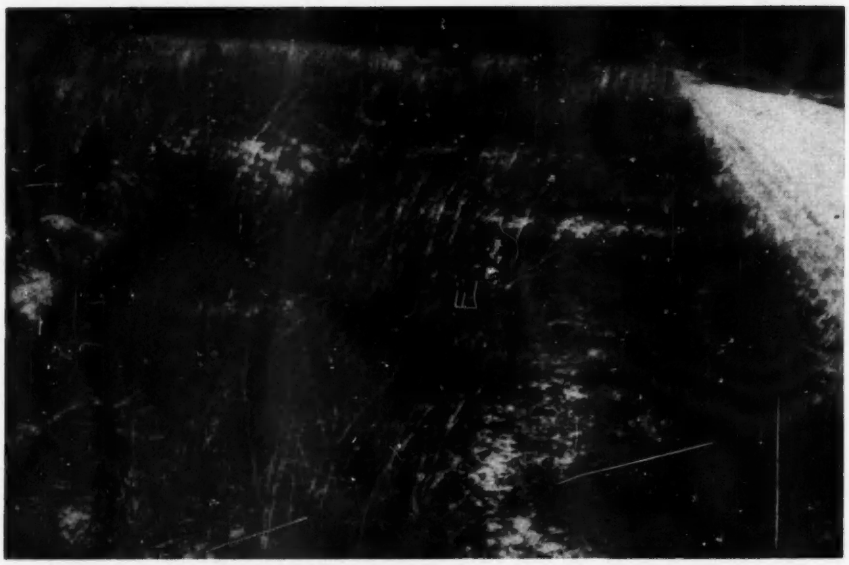


FIG. 20. A contact between soils, marked by a small stream. Beyond the stream dark red soil on basic rock is well wooded, and tall grass grows among the trees; the road is red. On the near side of the stream buff soil on granite bears only a patchy stand of grass and low brush; the road is yellow. The wooded land, owned by a European, is fenced, and grazing is kept within the carrying capacity of the pasture. The open land is Native Reserve. It is overstocked, and all trees have been cut for hut poles or firewood.

where its relief is not appreciably different from that of the land on either side. Near the ends it asserts itself as low mountain ranges, bearing grass. In the hilly section near Selukwe, mahobohobo trees (*Uapaca* sp.) dominate, and the stand of grass is poor. For the rest of its length, more than 100 miles, the Dike marks a break in tree species without bearing any distinct plant association of its own.

The soils weathered from basic rock were too heavy to be worked by the implements available to Africans before Europeans came to settle in the country. If used at all, these choice High Veld soils served as occasional pastures.

The contact between the two main types of soils found on the High Veld is dramatically sharp in many places, especially where a stream or a bog has developed on the line between the contrasting bedrock formations (Fig. 20). Where the land traditionally farmed by Africans has been set aside as reserves, and Europeans have settled upon the adjacent heavier soils, the contrast in productivity is painfully apparent. The juxtaposition is common because of the way European occupance was guided by natural resources.

The twin objectives of outlanders in south central Africa have traditionally been trade and missions. The Arabs took slaves and converted them to Islam from an early but unknown date, and they kept up the practice until the late 19th century. During the 16th century the Portuguese also enslaved and converted. Both groups bargained for ivory and gold also. The British government undertook to stamp out the slave trade, but the first Britons to enter the country beween the Limpopo and the Zambezi were missionaries and ivory hunters. Some of the latter were hired to lead parties seeking gold, and when Europeans began to enter the country in force, they also came looking for gold. That quest took them directly to the heavier, fertile soils, which commonly overlie the metamorphosed rocks where gold and other minerals are most likely to be found. Men attracted by the soil were able to settle upon it because it was not in periodic farm use by Africans. It was easily worked with the aid of European farm implements, and it proved to be the best soil for maize, the preferred cereal grown in the region. Even the western livestock ranches were likely to include the heavier and richer soil, because it was moister than the sandy lands. During the first years, however, most of the immigrants were prospecting for gold. Farming followed slowly.

Steps Leading to European Domination

In the latter half of the 19th century, several moves were made by Europeans with respect to the south central interior of Africa. A commando of Boers made a foray in 1847; missionaries lived in the area from the 1850's; news of gold deposits was published in 1867; hunters spent long seasons seeking ivory, beginning with the 1870's; a concession to mine gold was obtained from the most powerful ruler in the region in 1888, and a patent from the British crown chartered a joint stock company in 1889.[13] The authorizations were procured by Cecil Rhodes, and in 1890–91 he took the steps that eventuated in the British colony of Southern Rhodesia.

The High Veld could be approached along three lines (Fig. 1). The shortest

[13] Lo Bengula, King of Matabeleland, Mashonaland, and other adjoining territories, . . . granted to the concessionaires and their assigns, "the complete and exclusive charge over all metals and minerals situated and contained in his Kingdoms, Principalities, and Dominions, together with full power to do all things which they may deem necessary to win and procure the same." [The] Royal Charter . . . empowered the company *inter alia* "to carry into effect divers concessions and agreements which have been made by certain of the chiefs and tribes inhabiting the said region, or elsewhere in Africa, with a view of promoting trade, commerce, civilization, and good government in the territories which are or may be comprised or referred to in such concessions." Brown, *op. cit.*, pp. 44–45.

route from the seaboard lies to the east, across the flat, often flooded, and always malarial plain long claimed by Portugal as the hinterland of its ports on the Mozambique coast. Late in 1890 small military detachments under Portuguese and British flags moved between plateau and plain, and skirmishes occurred. Negotiation was substituted for force and half a year later a boundary was drawn along the face of the plateau. Britain thus obtained the salubrious High Veld but it was landlocked by Portuguese territory. Access to the seaports from British territory was guaranteed.

A second approach required crossing the Limpopo, a stream fordable in the dry season, but lying in a broad trough of Low Veld rife with diseases. In the dry season of 1891 more than 100 restless Boers from the adjacent Transvaal crossed with the idea of occupying territory. British authorities promptly stopped them and escorted them back to their own country. Some of them later settled in the new colony, the vanguard of a migration that continues after 65 years.

The third natural approach lies to the west of the Limpopo Trough and keeps to high ground all the way from South Africa, and entering either along the watershed, as the railway now does, or via the Mangwe Pass just west of the Matopo Hills. The pass route was taken by the men who negotiated the mining concession at the Bulawayo kraal of the Matabele ruler of the area, but prospecting for gold was understood to be limited to Mashonaland, and no large-scale movement thither would be allowed to cross Matabeleland. Since the proposed occupation was based on British South Africa, a route that crossed the Limpopo Trough was the only choice (Fig. 14).

Equipped with authorizations from the governments in England and in Matabeleland, the British South Africa Company (generally called the Chartered Company) gathered 180 "pioneers" and 500 police near Mafeking, at the northeastern corner of the Cape Colony. This quasi-military force trekked northward, keeping to the best-watered margin of Bechuanaland, but avoiding the hostile Boer Republic of Transvaal. They set up a base near the Macloutsie River, an affluent of the Limpopo, in thick bush near the lower margin of the Middle Veld. There, on the boundary of friendly territory, 200 police were left to keep open a line of retreat. Fifty miles farther on, a company warehouse, protected by a fort, was built at Tuli, on the Shashi tributary of the Limpopo. Although in the Low Veld, an embryo boom town sprang up about the fort, made up of private purveyors of goods and services.

The trek was planned for the dry season, because then the trail would not turn to mud, the wide riverbeds were largely dry sand, and the menace of malaria and sleeping sickness was at a minimum. Unfortunately, visibility is low in the thick bush even during the drouth when the trees stand leafless. Hence there was always the danger of ambush by young Matabele warriors, who were known to be lurking in the vicinity. The expedition started from Macloutsie in late June, 1890. A gang of African road builders, escorted by 300 mounted police, was followed by the Pioneer Column, likewise armed and on horseback, and a train of more than 100

ox-drawn wagons. Every man had been promised the right to prospect for gold and to file fifteen mining claims, once they reached their goal on the High Veld of Mashonaland. The plateau was familiar to the guide, the hunter Frederick C. Selous, but he had never been in the Low country that had to be traversed and knew of no route threading the dissected Middle Veld. It took a little more than a month for the Column to reach the base of the plateau, after crossing the Lundi River (Fig.

FIG. 21. The low Veld along the Lundi River, looking toward the dissected margin of the plateau. The present road from Fort Victoria on the High Veld crosses the Lundi on the low-level bridge shown, and runs to Beitbridge, where a railway from Transvaal terminates on the north bank of the Limpopo River.

21), and the guide rode ahead to examine the country "and look out a good line for a waggon road." On climbing a high hill,

> I could see one opening indeed, leading straight into the hills, exactly on the line that I wanted to take . . . [It] looked as though it might take one far into the broken country. I resolved to explore it. . . . Down its centre ran a fine clear stream of water —the Godobgay. This valley we now followed up, and as it led us mile after mile into the broken country, always ascending gently and regularly, and always running exactly in the right direction, my heart beat high with hope that it would lead me right on to the open downs of Mashunaland, and thus prove to be an easy open pass through the only piece of country in which I had anticipated any difficulty in finding a road for heavy waggons.
>
> When the sun went down . . . I . . . cantered on by myself up the pass. About a mile ahead stood a small rocky hill whose summit rose well above the broken ridges by which it was surrounded. This hill I climbed, and my feelings may be better imagined than described when I say that I saw stretched out before me, as far as the eye could reach, a wide expanse of open grassy country, and knew that I was looking over the south-western portion of the high plateau of Mashunaland.

> As I stood alone on that little hill on the evening of 3rd August 1890, and looked first forwards across the grassy downs, . . . and then backwards down the easy pass by which I had ascended . . . a weight of responsibility, that had at times become almost unbearable, fell from my shoulders, . . .[14]

Ten days later a road had been cut in "Providential Pass" and the wagons were pulled through it—a rise of 1,500 feet in eight miles. Near the edge of the High Veld they built and garrisoned Fort Victoria (Fig. 14) and farther north Fort Charter. They pitched their last camp and built their last fort, Salisbury, a dozen miles short of their announced goal. This was to have been a conspicuous landmark, Mt. Hampden, at the head of the extensive grassland known as the Gwebi Flats. Instead, they stopped at a steep-sided hillock alongside which was a bog, and there the business of the town was first carried on.

Gold, Touchstone of European Settlement

Gold deposits are widespread on and near the surface of the High Veld (Fig. 22), and they have been worked for an undetermined number of centuries. Until the British introduced European methods, mining had been confined within narrow limits.

Pits were dug only to the water table, and the deepest recorded reaches no more than 120 feet, others 60 to 70, and most of them far less. In these upper levels the ores are oxides from which gold can be recovered by breaking up quartz reefs in which it is embedded. This the African miners accomplished by setting a fire against the ore face and quenching it with water. Iron picks were used to extract the cracked rock, which might be heaped along with wood for further burning, before being crushed by hammering with selected stones, brought to some of the mines from distant sources.

Probably every ore body in the country was known to the early miners, but they worked only the richest parts of the reefs. They also washed gold in river beds, but no stream has been found productive enough to repay European panners.

Most members of the Pioneer Column turned to prospecting for gold, and they were joined by a rush that totalled some hundreds of men in the first year. Many were caught on the Low Veld by an excessively wet season that filled the river channels with turbulent floods and blocked both miners and food-trains bound inland. Rain turned the Pioneer Road to mud that mired wagons between rivers. Everywhere rations became very short, even when supplemented by purchases of millet and melons from African farmers. The wet weather favored mosquitoes, so malaria was more of a scourge than usual, and many died of it or from starvation.

Those who reached the High Veld found that local tribesmen could lead them to the many scattered pits that had been dug by African miners and nearly every European gold mine began on African workings.

African Resistance

Swift deployment of gold seekers over Mashonaland interfered with Matabele raids upon that territory, but young warriors did continue to make forays. Attacks

[14] Selous, *op. cit.*, pp. 375–76.

culminated in killing several Mashona at Fort Victoria, some three years after its construction. The Chartered Company then sent a military force into Matabeleland, defeated the warlike tribesmen on their own domain, and marched to Bulawayo, to find the paramount chief fled and his kraal in flames.

The remaining tribesmen, whose forebears had hidden in the Matopos fifty years before on their way to conquest, made a last stand in the same hills. Rhodes,

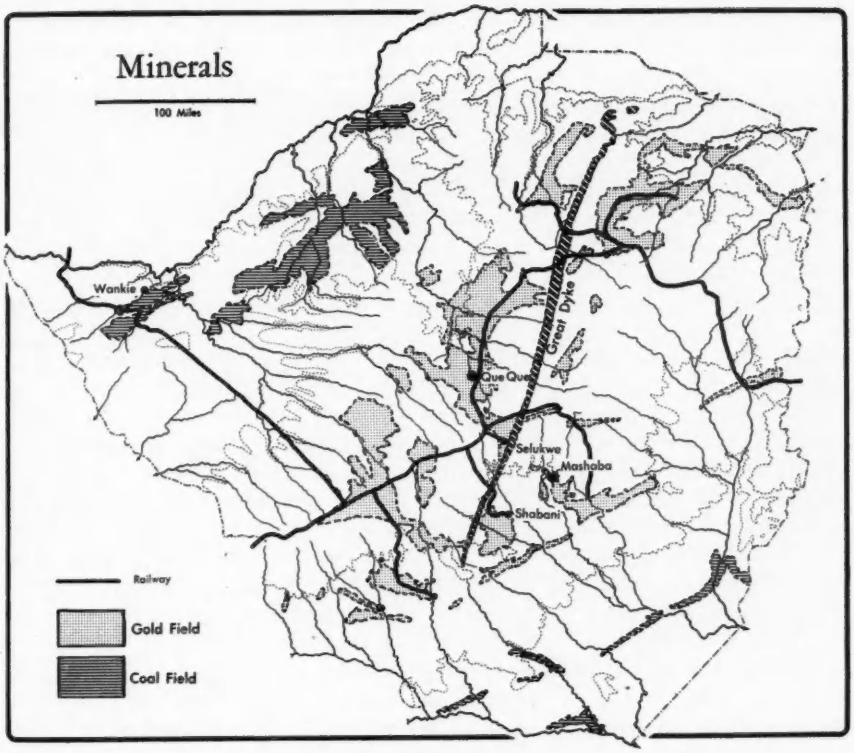


FIG. 22. Principal minerals.

whose vision and will had instigated and carried through the British occupation of the country afterward named Rhodesia, camped unarmed in the wilderness nearby and brought the revolt to an end by a palaver. This courageous feat is generally considered his greatest exploit.

The arduous, malarial, and roundabout road cut for the pioneers was forthwith abandoned in favor of the route along the High Veld (Fig. 14). On the site of the Matabele kraal, Bulawayo, near the huge tree under which the departed chief had given his rulings, a "Government House" for administering the territory was built,

as a demonstration of the superior power of the conquerors. Two miles south, a trading town, also called Bulawayo, was laid out along a streamlet.

Prospectors and ranchers quickly spread over Matabeleland. Interference with tribal activities by these newcomers, and resentment of the leaders at restrictions imposed by British rule, including a ban on raiding, produced a revolt less than three years after the conquest. The occasion was a combination of calamities: drouth, a visitation of locusts that consumed the pasture, and an outbreak of rinderpest, a cattle epidemic that took off a large fraction of the livestock. Many Europeans, caught unawares at their isolated mines and ranches, were slain, and the Matabele left the Mangwe Pass open in the hope that the rest would flee. Instead they defended themselves as best they could until imperial troops reached them. A quick campaign drove the Matabele once again into the Matopo Hills, where the leaders capitulated seven months after the trouble began.

Fired by the Matabele example, the Mashona flamed into spontaneous rebellion. Following their long-standing habit of taking refuge among their castle hills, they withdrew on the approach of British forces to "an almost impenetrable . . . line of defence. The gigantic rocks piled up in confused masses formed countless caves . . . and provided cover which they were expert at turning to advantage. . . . Without exposing themselves they were able to use their flintlocks at close range with deadly effect." Because each chief operated independently, nearly every refuge had to be taken separately. "The breaking up of [one] important stronghold, which for twelve months had been the head-quarters of . . . witchdoctors and the central rallying point of the rebel leaders, . . . was soon followed by the surrender of most of the remaining chiefs."[15] Fifteen months passed before the last of them surrendered. The Mashona were then forbidden to maintain villages in rocky and inaccessible positions. That ruling has since been somewhat modified to permit villagers to set their huts and granaries on the clean and vermin-free surfaces of bare granite protuberances. Such settlements are not fortified (Fig. 13).

Once the insurrections had been put down, the country evolved under British direction on the double environmental base of minerals and farmland.

Mashonaland and Matabeleland remained distinct, particularly in agricultural use of the land. But a name for the entire area was required and was happily supplied as an honor to Cecil Rhodes, who had had the vision of a British Central Africa, and made his dream come true. His Chartered Company defrayed the cost of the Pioneer Column and the wars with the tribesmen; it built the telegraph lines and railways within its domain and beyond, to connect with established communications by land and sea. No wonder that it continued to have an annual deficit for 16 years (until 1907). By experimental example, it encouraged livestock ranching, citrus orcharding, and sugar and tea planting. But its earliest concern was mining.

Crises in the changing relations of the Company to the settlers mark stages in the country's growth from dependent beginnings, to emancipation from the Company, to a large degree of independence, and to leadership in south central Africa.

[15] Hugh M. Hole, *The Making of Rhodesia* (London, 1926), pp. 377–378.

MINING

Gold was the lure that brought the first large immigration (Fig. 22). Deposits are widely scattered, but occur chiefly among the metamorphosed rocks of varied origin, or along their planes of contact with the surrounding granite. By exception, none have been found along the Great Dike. Most of the ore bodies are small, many are faulted, and few promise long life. The oxide ore, being near the surface and free-milling, is easily mined. These conditions favor the small operator—an individual or a very few men, equipped with a battery of three or five stamps for separating the gold from its matrix.

FIG. 23. The pithead and tailings of a gold mine ranking medium or small among Rhodesian mines. North of Que Que.

Gold at once became the foundation of the country's economy. Until lately it yielded annually about half the national income. Having got the concession to seek gold, the Chartered Company regulated the movements of prospectors and miners, who were required to work on a basis whereby the Company took over the output and kept half the profits. In 1903 a royalty paid to the Company was substituted, with small payments on small diggings and increases with scale of the operation. The change fitted the scattered and small-scale occurrence of gold ore, and within two years was rewarded by a sharp increase in the total output, thanks to small producers. A great many outfits turn out less than 500 ounces of gold a year, and some operate intermittently; yet in 1942 they contributed 12 percent of the country's total. These very small workings, together with mines yielding between 500 and

5,000 ounces (Fig. 23) numbered 1,500 before World War II and only 650 at the end of it. Of the casualties, many were mined out. In others the oxide ores were depleted, and the owners lacked the capital and technique to work the deeper-lying and more refractory sulfide ores. Some mines were too small to repay installation of labor-saving machinery.

Between 20 and 25 mines produce more than 5,000 ounces apiece, and about ten of them turn out 10,000 or more (Fig. 24). These last named produce nearly half the total and along with several smaller ones are working sulfide ores. The average life of the larger mines has been 16 years, although two have operated more than twice as long. Reserves in sight are not large, even in the most favorable ore bodies.

FIG. 24. One of the larger Rhodesian gold mines, the Etna, near Gatooma. The cone and the terrace at its left are tailings. Housing for the African workers and their families lies beyond the chimney and pitheads in the distance.

Neither mining nor government officials anticipate that any extensive ore bodies like those of the Transvaal and Orange Free State will be found. The government aids gold miners in several ways: by free assaying of samples, by loans, and by free drilling (repaid if the mine proves out). In 1937 a government roasting plant was built to encourage production of sulfide ores. It is at Que Que, a central location.

In 1933 the Chartered Company sold its mineral rights to the government of Southern Rhodesia for £2,000,000. This is considered to have been a profitable move for the buyer, not so much because of gold as because of other minerals which have been overtaking gold in value of output, chiefly asbestos and chromic iron ore. With the war, gold production fell off, while the others, needed for prosecuting the war, were stimulated. Toward 1950 the three minerals were approaching equality in value. At that time the royalty on gold was eliminated in the hope of offsetting

increasing costs of mining deep sulfide ores. In 1951 minerals lost the collective lead they had maintained from the beginning, being exceeded in value by aggregate agricultural production.

Base Mineral Products

While gold was the magnet that first attracted immigrants to High Veld, other minerals have since made varied contributions to the regional economy (Fig 22).

Asbestos has been mined since 1908, and its annual value now equals that of gold. The known deposits occur in small areas of serpentine at Shabani, where unified

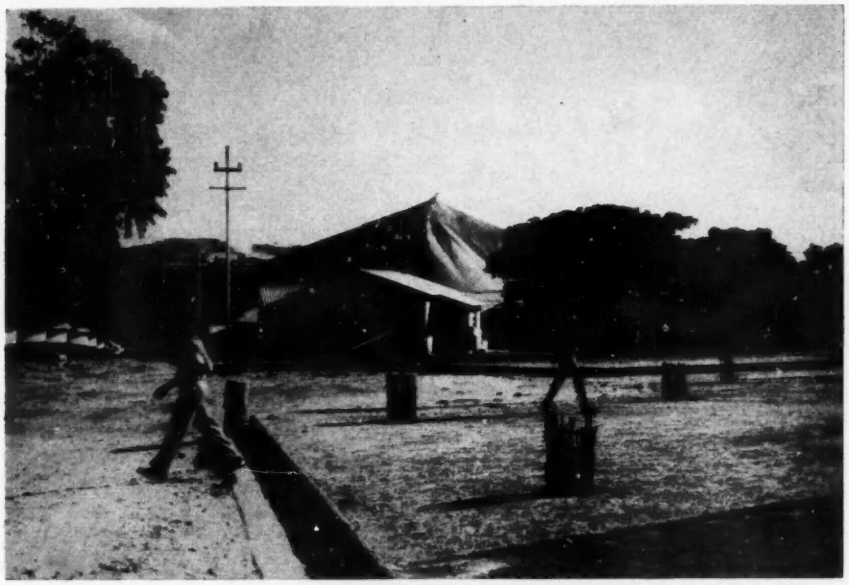


FIG. 25. An asbestos mine and a waste heap, Shabani. In the foreground is housing for African workers; at the left a line of old-style conical huts of adobe walls and thatch roofs; at the right newer, two-family houses of concrete blocks and corrugated absestos roofing. *Courtesy of the Southern Rhodesian Government.*

operation is on a large scale, and 35 miles away at Mashaba, which lacks rail connection and has smaller works. Much of the output is of the most valuable variety, and the total places Southern Rhodesia third among world producers. The glistening white piles of waste (Fig. 25) and expanses of the golden bedrock in a setting of steep, bush-covered hills make a striking landscape. A newly built, small business center and villages for both Europeans and Africans with houses under shade trees complete an attractive picture (Fig. 26).

Chrome ore has been mined since 1907. The output has reached two-thirds the value of asbestos or gold in some recent years, and ranks Southern Rhodesia seventh among world producers. Chromic iron occurs at a number of places along the

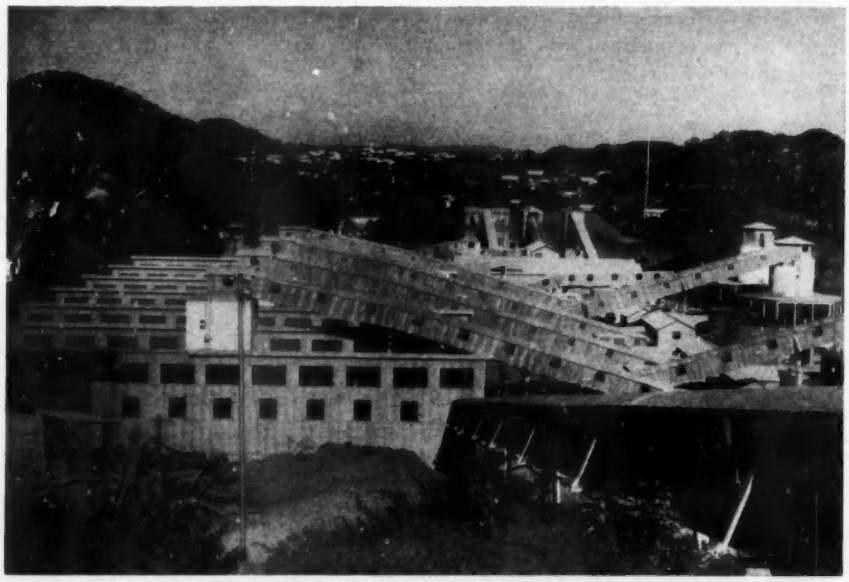


FIG. 26. A mill at the asbestos mine, Shabani. In the background is the European residential and business quarter. *Courtesy of the Southern Rhodesian Government.*

FIG. 27. Mining chromic iron ore by drifts into the hillsides. The view is taken from Selukwe Peak, and the sweep of road and railroad emphasizes the rugged terrain.

Great Dike, especially in its hilly parts (Fig. 27). At the chief mining center, Selukwe, local relief ranges up to 1,500 feet. There, open pits are worked to a depth of some fifty feet; deeper workings are underground (Fig. 28). Mines and residences are served by roads, but the ore is brought down by light railway to the end of the branch that links Selukwe to the main line. Houses for Europeans are set among native trees on the hilly terrain. Africans live in standardized rows of huts scattered among the mines. The ore is a bulky product to ship from interior Africa, and a mill for making ferrochrome has been built at Gwelo, where the Selukwe branch of the railway joins the main line.

FIG. 28. Works and tailings of the Tebekwe underground chrome mine at Selukwe. The pit headframe is out of sight at the left.

Coal, mined since 1906, is perhaps the most important mineral in the country, although the value of a year's output is only a quarter that of gold or asbestos. Its tonnage is nearly twice that of all the other minerals combined, and the whole of it is used in Central Africa, to run the railways and for mining and manufacturing. Coal underlies some 400 square miles of Low and Middle Veld, some in the southeast but most in the northwest. It is mined only at Wankie, where the railway crosses one of the fields (Fig. 29). The chief coal seam, 40 feet thick, lies only 150 feet below the surface, and is reached by ramp which can be used by motor vehicles, and up which laden cars are hauled on an endless chain. The mining camp is hot and remote compared to mineral workings on the High Veld (Fig. 30). All its markets are at a distance, and transportation increases the cost to a level that encourages competing hydro-electric installations, as in Katanga, Belgian

FIG. 29. Wankie, the coal-mining town. Laden cars await shipment. In the middle distance are the condenser and chimneys of a carbo-electric plant.

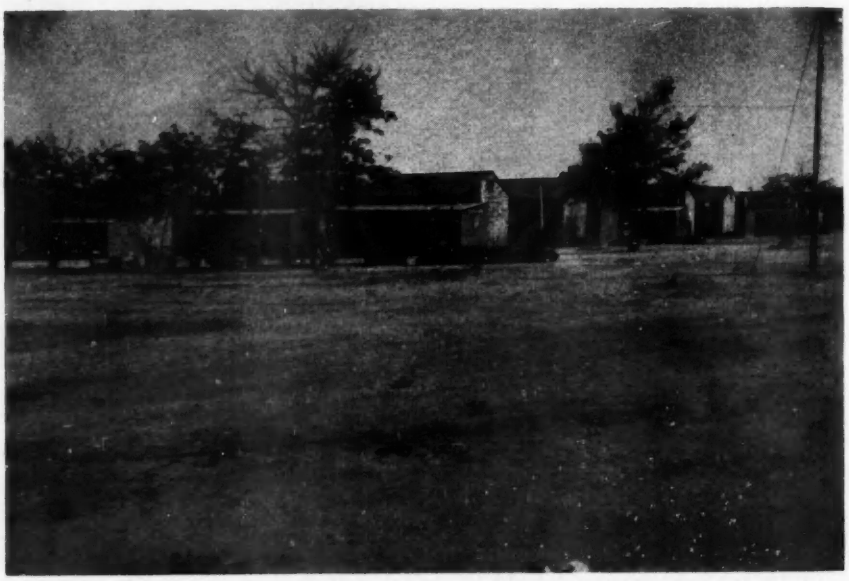


FIG. 30. Housing for African coal-mine workers at Wankie, in the hot, dry Middle Veld.

Congo. The one factory located at the Wankie mine is a kiln for burning refractory bricks.

Superficial iron deposits were worked by Africans, and large ore bodies are found in several of the schistose areas known for gold and other minerals. Only one has been tapped, a few miles from Que Que, where iron and limestone occur close together and conveniently near the main railway line. The value of iron and limestone mined is far below that of the four leading minerals.

A score of others are produced in small quantities. Among them are tin and copper, which had been worked by Africans, but no large deposits have been found. Tungsten outranks all but the four leaders in value of present production and expectation of increase. Its ores are widely dispersed in the schistose districts.

All mines are operated by a few Europeans and many Africans, but some are more highly mechanized than others, thus reducing the proportion of Africans employed. In recent years approximate figures have been as follows:

Mineral	*European employees*	*African employees*
Gold	1,500	40,000
Asbestos	425	9,000
Chrome	140	5,000
Coal	190	5,500
All minerals	2,300	60,000

More than three-quarters of the Africans employed in mining come from outside Southern Rhodesia on a temporary basis, and many of the rest take jobs at a distance from their tribal homelands. Those who care to make gardens are by custom allowed to use land in the vicinity of the mine, although without legal right to it. Damage to such farmed lands has resulted from careless methods, and the mine operators have now been made responsible for proper control of fires, erosion, and other threats to the soil.

URBAN ACTIVITIES

European life in Southern Rhodesia has always had an urban cast, beginning with mining camps on the early gold finds. Some of these became outfitting points for several mines, notably Que Que, with eighty in its vicinity. The stores in such towns came to stock merchandise for farmers and ranchers as well as for miners, and later some manufacturing crept in. Several of the urban communities have this background. The two large regional centers, Salisbury and Bulawayo, also serve mines but owe their primacy to central location in Mashonaland and Matabeleland, respectively. They were given administrative functions at the outset, and at once became the chief trading towns and manufacturing centers of their respective districts.

Manufacturing

Although factories are not conspicuous in most of the cities and large towns, their number, size, and variety have greatly increased since imports were drastically

cut by World War II. The impetus has continued, and manufacturing is contributing to the economy faster than any other aspect of business.

Mining camps have always processed their output to the extent of concentrating ore as a step in sending it to a remote market, generally overseas. In that restricted sense manufacturing is as old as European occupance.

Over the years another group of processing plants has grown up to satisfy the local markets. Flour mills (Fig. 31), bakeries, breweries, and foundries are samples. They are located in the larger towns regardless of the source of their raw materials, because they sell their products within a short distance of the factory.

FIG. 31. A large flour mill at Bulawayo, served by the railway as well as by broad streets for trucking.

Some manufacturing industries that supply the home market are located where bulky, heavy raw materials are available. The only commercial stand of trees in the country is north of Bulawayo, where the small bush is dominated by a hardwood known to the indigenes as mgusu and to the trade as African teak (*Baikiaea plurijuga*). It occurs on soils derived from mixed lavas and sandstones at the margin of the High Veld. The wood is cut where the railway taps the forest, and is sawed before being sent to market. It is used for railway ties, flooring, and furniture. Bricks are made of suitable clay deposits, perferably near a town (Fig. 32). Cement is much needed for construction of buildings and roads, and for water-pipes in a land where water is the most critical natural resource. Factories are located where railways reach abundant deposits of its raw material, limestone. Another

local mineral, asbestos, is increasingly used along with cement to make roofing. It combines the virtue of thatch (coolness in summer and warmth in winter), with the virtue of iron (proof against fire).

Factories not tied to local markets or localized raw materials are being installed in the two old district centers, Salisbury and Bulawayo, and also in the "Midlands" between them, where several smaller towns are gaining recognition as key points in an increasingly coherent district.

FIG. 32. A brickyard at the edge of Selukwe, on a suitable clay associated with the Great Dike.

One such town is Gatooma, where the government built a cotton spinning mill during World War II (Fig. 33), and set up an agency to run it.[16] The demand for cotton goods was increasing, especially for blankets, cheap prints, and coarse cloths wanted by Africans. The cotton plant thrives in many parts of Southern Rhodesia, but private capital did not assume the risk of building textile factories to process locally grown fiber. The government spinnery, built when ocean shipping was scarce, exemplifies a policy of capitalizing and indirectly operating desirable ventures that private firms do not undertake. It continued to be succesful after the war, and a new building has been added. The yarn it turns out is woven or knitted in privately owned and operated factories at Gatooma and other places along the rail-

[16] In Europe, the Americas, and Asia, textile manufacture has signalized the shift from handcrafts to machine production known as the Industrial Revolution. In Southern Rhodesia government initiative is fostering and hastening the change to an uncommon degree.

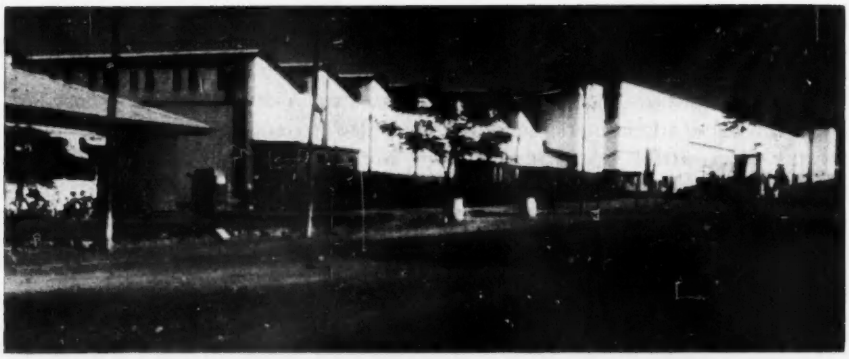


FIG. 33. The government-built cotton spinning mill and its extension, located on the railway and highway at Gatooma.

way. Some of the product is exported, chiefly to the Union of South Africa. To assure a supply of raw cotton, the government guarantees a reasonable price to both African and European farmers. This works to the advantage of the soil, because

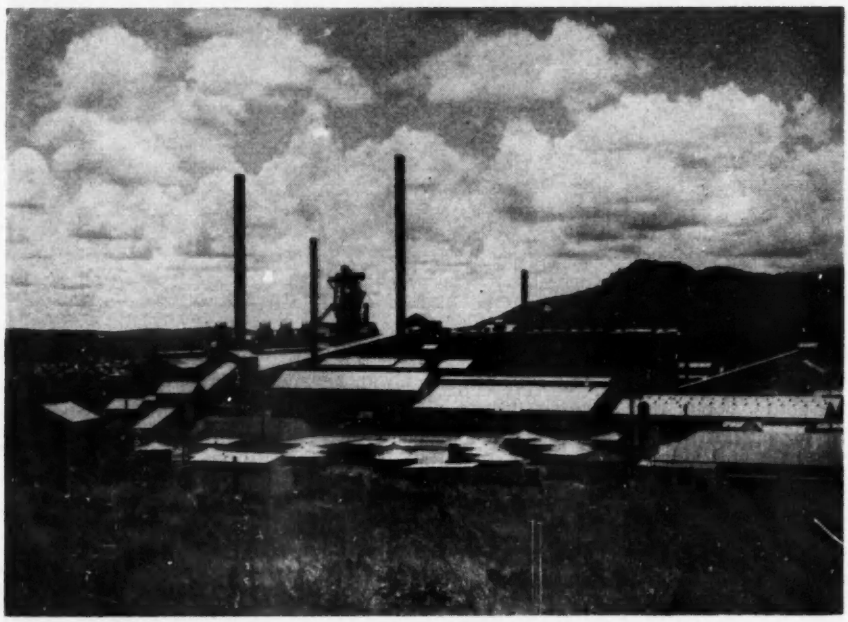


FIG. 34. The steel works near Que Que, showing the blast furnace and coke ovens. The ramps bring iron ore from the mine. At the left is housing for African workers in both mine and mill. *Courtesy of the Southern Rhodesian Government.*

FIG. 35. Blasting limestone from a quarry almost adjacent to the steel mill.

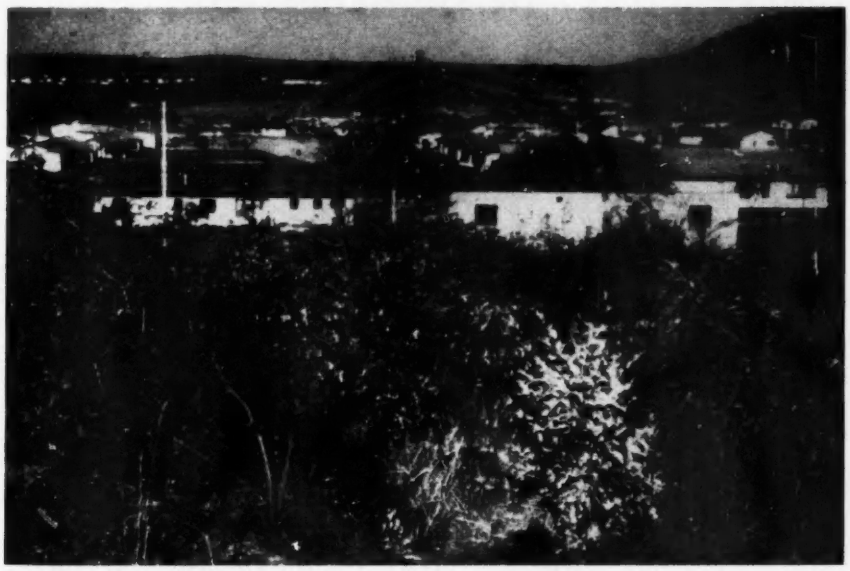


FIG. 36. Company-built housing for Europeans employed in the steel mill and associated enterprises.

cotton is valuable in crop rotations. The cotton seed is pressed for edible oil and soap, the seedcake being consumed by dairy cattle.

A second government undertaking precipitated by the war sets Southern Rhodesia still farther along the road to self-sufficiency in manufacturing. An agency created for the purpose has built a small but complete steel mill (Fig. 34) in the Midlands, some seven miles from Que Que, long a leading gold-mining town. A short branch railway taps a large body of hematite ore, grading to magnetite, that can be mined in open pits. A quarter of a mile away is a large outcrop of limestone (Fig. 35). All operations of mining and smelting are mechanized so far as possible. African workers are housed near the mine and mill (Fig. 34). Busses bring

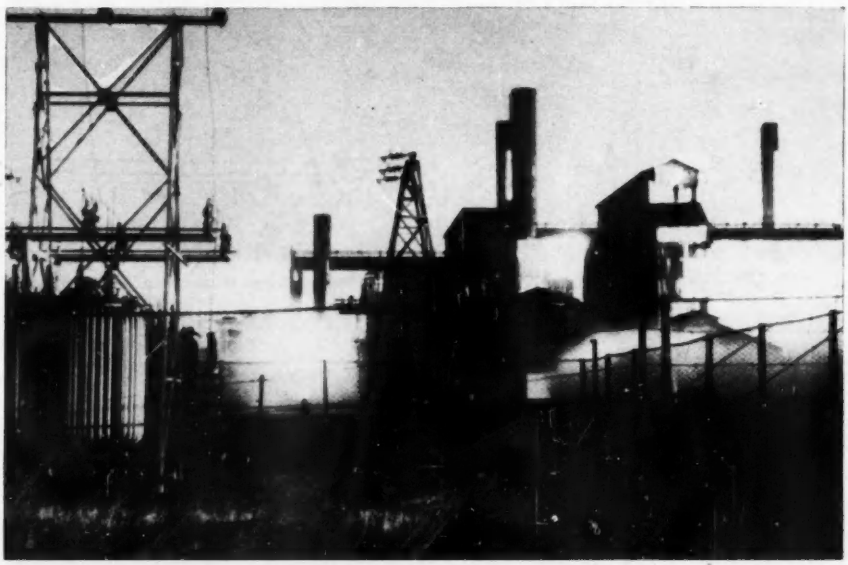


FIG. 37. The carbo-electric plant built to furnish power to the Que Que steel mill and to mining and manufacturing generally throughout the Midlands.

Europeans from company housing (Fig. 36), set apart from the works by a range of hills but only a mile away.

Fuel must be brought in from Wankie, 350 miles distant, where there is a large deposit of both superior coking coal and steam coal for producing electric power. At the steel mill there is not enough water for the condensers of a carbo-electric plant, and the government has built a large power station where the railway bringing coal crosses the perennial Umniati River, some 18 miles north (Fig. 37). Additional water for cooling is provided by dams on this and a neighboring stream. This power reaches the entire Midlands, in addition to the steel mill. Both the mill and the power plant have been hampered by a shortage of railway cars that has been

chronic ever since the war. The coal field (Fig. 22), tapped only at Wankie, comes within 100 miles of Que Que, and a direct railway connection is being urged to open a handier coal-mining center.

Thus far most of the steel turned out by the mill has been used for pipe, structural shapes, and wire, but plows and window casements are among secondary steel products manufactured in private plants.

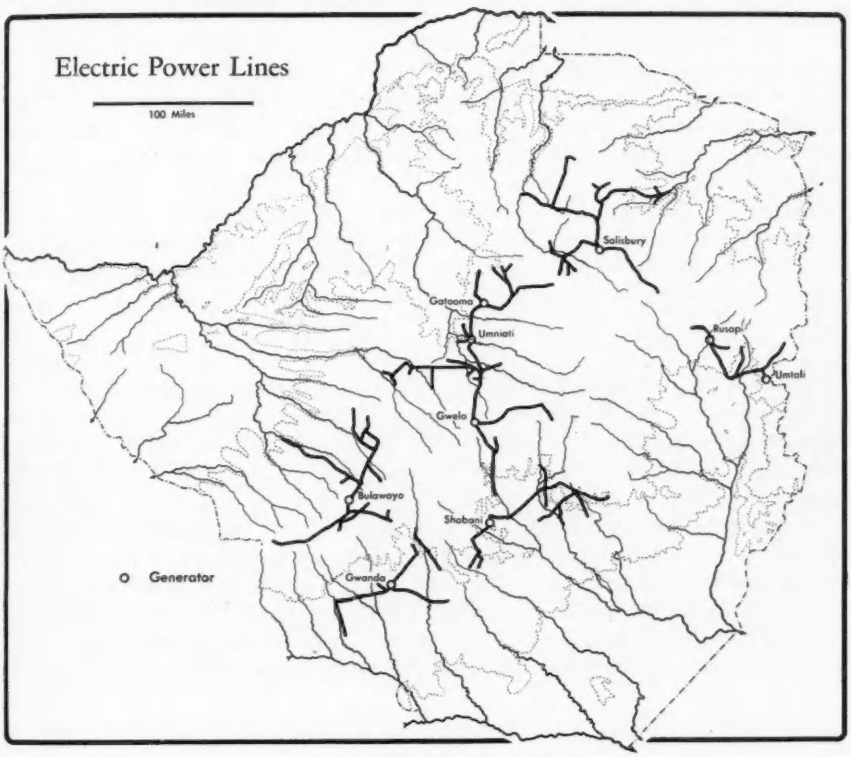


FIG. 38. Electric power lines.

Altogether a score or more kinds of goods are manufactured in Southern Rhodesia, thanks to a local supply of raw materials, local demand, or more often both. Leather goods and plywood are samples.

In the 1920's electricity was available in only the three largest towns and two important mining centers. By the 1950's all the towns and many mines had power plants, and in the more populous areas lines on wooden or steel poles carry electric current far into the country, to form an incipient network (Fig. 38). Coal from Wankie is the fuel used for all the electricity thus far generated. It has been proposed that the two Rhodesias join in damming the Zambezi at the Kariba Gorge,

and studies of the river's regimen have decided the Central African Federation to undertake a hydroelectric installation to produce 740,000 kilowatts throughout the year. The lake, 150 miles long, will store much of the rainy-season floodwater. The High Veld of Southern Rhodesia and the mines of Northern Rhodesia lie within a 250-mile radius of the dam site. Abundant power is looked to as the solution of the chronic coal shortage and beyond that as a means of industrialization to provide jobs for the rapidly increasing African population.

A little more than one-tenth of all employed Africans now work in factories, including a few women. This marks a rise of 73 percent between 1946 and 1951. Most employees tend machines and are rated as semi-skilled, but a few have advanced to skilled jobs. In the printing trade, Africans are found only where they publish their own newspapers. This may reflect the politically sensitive nature of the publishing business.

Secondary manufacturing is confined to towns along the mainline railway from Bulawayo to Salisbury, except for Umtali, where flour is milled and concrete building materials are made for the market of the eastern highland. The factories of every town lie alongside the tracks.

Trade

While manufacturing has increased notably, the primary function of the cities and towns still is trade. The business centers, whether small or large, comprise more firms than usual in European or North American towns of the same population. Each trade center has a large tributary area of farm and ranchland, and supplies the wants of mining camps as well.

In the early days most goods were sold through stores that stocked all kinds of merchandise, and general stores persist. In addition the larger cities now have about as many different kinds of shops and services as would be found in business districts of equivalent size in the British Isles. Some are branches of British or South African firms, and all stock chiefly British-made goods. At the edge of each European business district is a block or two of small stores catering to Africans.

Urban Layout

Most towns were originally assigned much more space than their early citizens could use for urban functions. At Salisbury, for example, farmland could not be acquired within six miles of the center (Fig. 39), and townsfolk had difficulty getting provisions from the distant countryside. As the city has grown, most of the land on the periphery of the reserved tract has been laid out for urban residence, either European suburbs or African "locations." The irregular band of open space between them and the central city has been put to a variety of public uses, including experimental farms, airfields, and recreational parks.

The central city is always a European town (Fig. 40), although many Africans work there, and those who can afford it may trade in the shops, available to them through a separate entrance. The business district and its periphery of residences

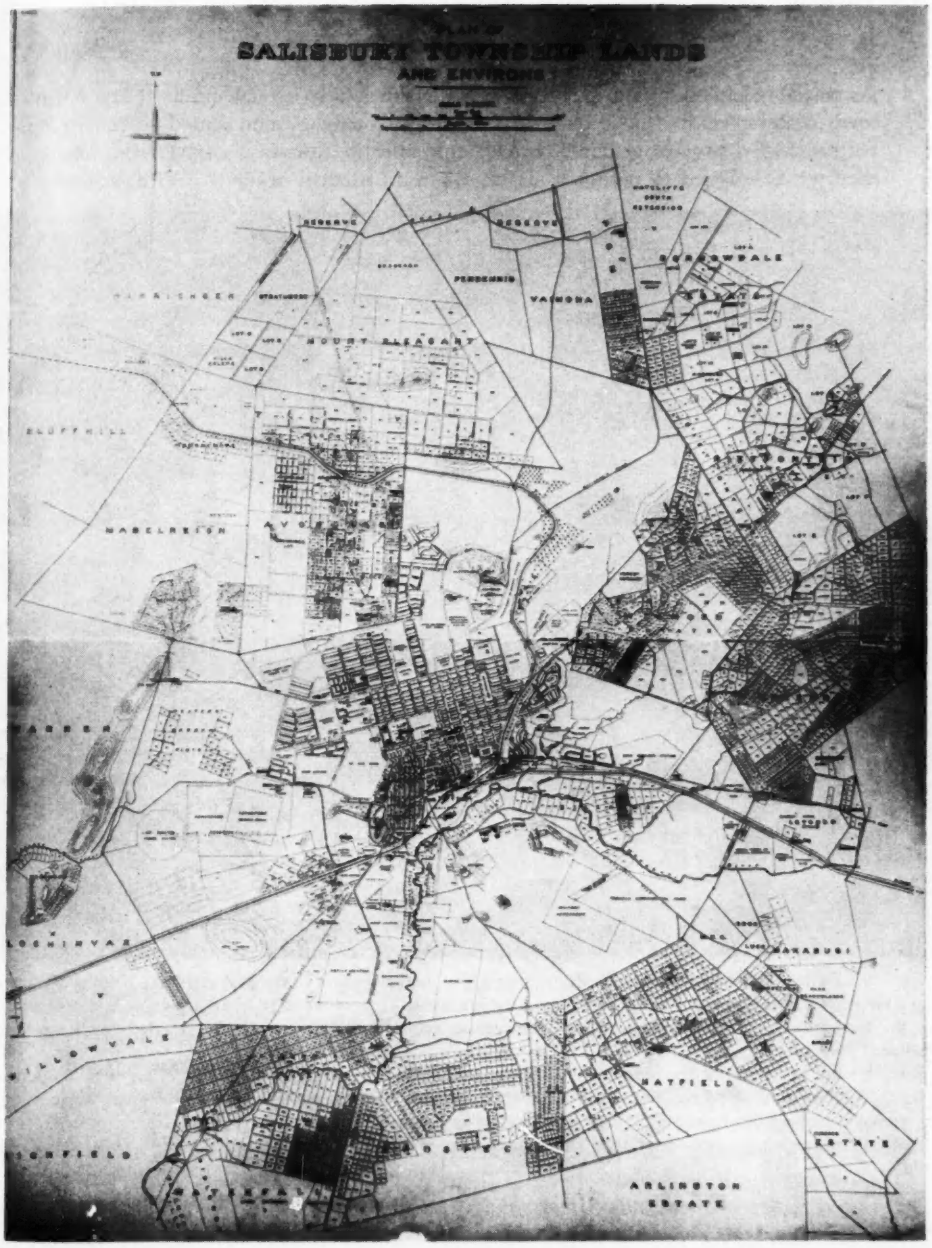


FIG. 39. The pattern of Salisbury, within approximately six miles of the public square. The two original street plats have merged to form the central city, with the fort hill at its southern tip. This built-up area of business, manufacturing, government, and residence is surrounded by open space, narrowest at the north, the dominant direction of European residential expansion. Beyond the circuit of unbuilt land are residential tracts for Europeans and Africans. There has been considerable construction since the map was drawn. *Courtesy of the Southern Rhodesian Government.*

is invariably laid out as a grid, even where the site is hilly, as at Umtali. (The other town centers happen to lie on level or gently sloping ground suited to the rigid pattern.) Streets are generally broad, especially in Bulawayo and Gwelo, where they were designed to permit a sixteen-ox team to turn around. With ox-teams

FIG. 40. Salisbury from the air. A segment of railway yards shows at the lower left; nearby are manufacturing and wholesaling; in the center, punctuated by tall structures, is the core of retail shops and offices; beyond it are the government buildings at the edge of the central city, there bordered by a wooded public garden and recreational park.

The fort hill and most of the pioneers' business street (shown in Figure 46) lie out of sight to the left of the tall white building that stands at the upper left corner of the built-up central city. The rival business district grew from the tree-set public square in the right middle distance.

In the background, beyond the ring of open space, are residential communities. *Courtesy of the Rhodesia Herald.*

rare in cities of today, the broad streets permit three lines of oblique parking for motor vehicles (Fig. 41). Residential streets are surfaced with gravel or crushed stone; downtown thoroughfares may be more durably paved, but perhaps only in the traffic lanes.

Most early business buildings were one storey high, and after six decades not many rise above three storeys. Since the war several tall structures have been built in Bulawayo and in Salisbury, where one has fourteen storeys. Sidewalks are generally covered and colonnaded for protection from the sun and rain; canvas curtains are let down to keep out early and late sunshine (Fig. 42). Some newer

FIG. 41. The broad main street of Bulawayo, showing the ample parking space and samples of sixty years of architecture. *Courtesy of the Southern Rhodesian Government.*

structures omit this "tropical" feature. Architectural style runs the gamut from "frontier" to ultra-modern. In each town a principal intersection is likely to be adorned with a clock or a heroic figure of Cecil Rhodes. Public buildings are massive; in Bulawayo and especially in Salisbury, the capital, they are grouped at one side of the commercial core.

Parks and sports fields are large and conveniently near the center of town. Grounds are laid out for cricket, bowling, tennis, football, golf, horse-racing, and, in the largest places, swimming. Throughout the year most late afternoons and all weekends are given over to outdoor sports. This is feasible because of the sunny weather which prevails in the dry season, and continues, interspersed with showers, the rest of the year.

The parks are noted for extensive and handsome displays of flowers, as well as ornamental plantings in a tradition brought out from moist England. Residential

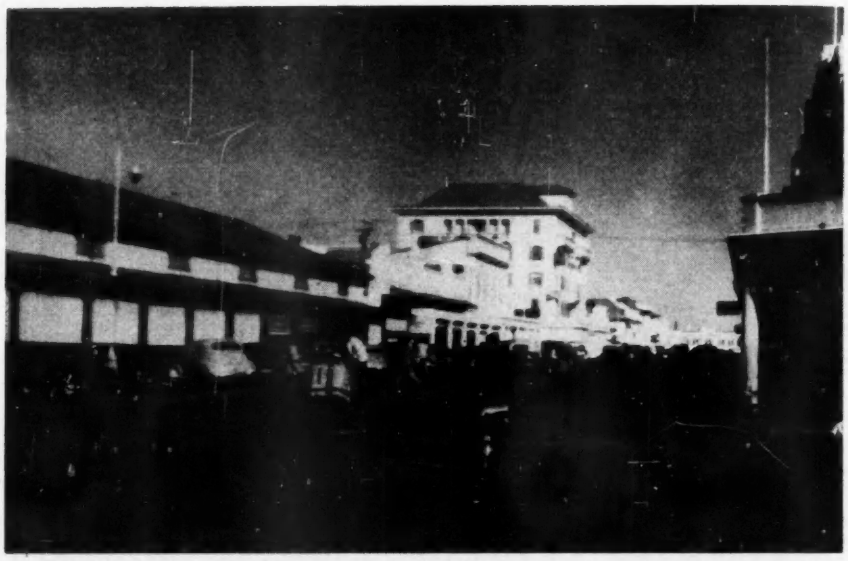


FIG. 42. An important business street of Salisbury, showing colonnades and curtains. Numerous bicycles are a feature of urban traffic in all Rhodesian towns.

FIG. 43. The reservoir that supplies the High Veld city of Gatooma with water. It has been created by damming a stream not far below its sources.

streets are lined with trees, many of them showy with blossoms in season. Some shade trees, and all gardens, require irrigation during the dry weather, adding to the draft of the towns on the water supply. Because several of the largest centers are on the watershed, and the rest not far below it, providing water has been difficult (Fig. 43). Some of the larger reservoirs in the country conserve urban supplies, but at the end of a run of dry seasons, shortage is likely.

Until after World War II, most people lived in detached houses (Fig. 44). Recently some blocks adjacent to the business centers of Salisbury and Bulawayo, the only places that would be thought of as cities rather than towns, are being rebuilt

FIG. 44. A European's house set in its own grounds, ornamented by eucalyptus trees and facing an unpaved street. This is in Fort Victoria, but is typical of all Rhodesian towns until the end of the second World War. The church is typical.

to apartment buildings (Fig. 45). European suburbs have been laid out beyond the original plats of half a dozen fast-growing towns. The street plans of some suburbs depart from the rectilinear, in order to make the most of rivulets and slopes, or merely to vary the monotony of right-angles (Fig. 39).

Salisbury has grown from two centers. The Pioneer Column disbanded at the base of a rounded hill that stood some 220 feet above the undulating, grass-covered plateau. The first businesses lined a street that skirted the hill and ran between it and a bog. It was better suited to defense than to commerce, and within a few months the Chartered Company set up an administrative and trading center on a

broad, gentle slope descending to a little watercourse (Fig. 39). Soon the bog was drained, its course being later preserved in a broad boulevard providing ready access to both the rival commercial districts and also to the principal government offices of the capital city. The town grew slowly for a long time, but gradually the gentle, naturally drained terrain won out as the site of the dominant business and residential areas.

FIG. 45. Multi-storey apartment houses in Salisbury, built since World War II. The hill behind was the site of the fort built by the Pioneer Column, and the first stores were set up along its base. The tree-lined boulevard in the foreground has succeeded the drained bog which originally separated the initial settlement from the rival plat that became the main business center of the growing city. *Courtesy of the Southern Rhodesian Government.*

Bulawayo was planted four years later than Salisbury. It grew faster for a time, first as the railhead for the South African base from which the new colony was being nourished, and later as the rail center. Ultimately it was outranked by Salisbury, but it has remained the metropolis of the drier half of the country.

Africans in Towns

About 317,000 Africans are employed in towns and cities (including mining

camps), where they live permanently or temporarily.[17] A small number are traders and craftsmen, who run their own businesses. They cater mainly to other Africans, but they may sell their wares and services anywhere in the towns. All the rest are wage earners in enterprises of the Europeans. In the Salisbury municipal area, which may be taken as a fair sample, 22 percent are in domestic service. Nearly all these are men who live, generally with their families, on the grounds of their employers. A few girls act as nursemaids to children. The other 78 percent—manual laborers, semi-skilled and skilled machine operatives, clerks and messengers in shops and government offices, and mine laborers—live in segregated suburbs called "locations." These lie some distance from the European city center, and are reached by bus or bicycle.

Mining properties are likely to be on the fringes of towns, and the locations for mine workers may look somewhat like those of the municipalities. The mining companies are responsible for them, and most of them are better built and more carefully supervised than any but the best city projects. Commonly the company feeds its African workers, thus insuring that they get proper nourishment. Laborers in the cities often skimp on food in order to satisfy other wants.

Many locations are set apart from European centers by a bush-fringed stream, or by a belt of woodland, a government undertaking, sports fields, or market gardens. Employers are supposed to provide suitable quarters, and a few larger firms attempt to do so, but very many workers have to make do with what they can find.

Most of the employed men live in urban areas temporarily, and return to their tribal village after a number of months or years. While in town, many of them change jobs frequently. Even if they are steady workers, their wage rate is so low that they cannot afford to pay rentals equal to the economic rent of decent dwellings. These three conditions have caused the larger towns to embark on public housing, but as yet there are not nearly enough units to accommodate the fast-growing African population. Even where the municipalities absorb some of the cost, the rentals are so high that they tempt unmarried men to overcrowd bachelors' hostels, and families often take roomers who must share bedrooms occupied by members of the families.

Some "villages" recently built by the towns for Africans are self-contained suburbs, with schools, churches, clinics, sanitary facilities, recreational grounds and halls, and land for gardens. One of the best planned, five miles outside of Salisbury,

[17] Wage earners are divided roughly as follows:

Occupation	*Percent of total*
Domestic service (including those on farms)	12
Mining	12
Manufacturing	10
Construction	9
Other	17
Total urban	60
Farm laborers	40

Source: *The African in Southern Rhodesia: Number Five—Industry* (Salisbury, 1952), p. 2.

has an orderly but diversified street plan. Family houses are commodious, made of stuccoed brick, stuccoed concrete, or a combination with tile. The roof is of corrugated asbestos cement. Each householder gets half an acre for a garden. The government supervisor encourages interested Africans to plan cooperative improvements and social programs. A good many live in the European manner, as they are among the most progressive and industrious workers in town. There is a waiting list for houses. Priority is given to men who work steadily and show increasing skill on the job. The policy looks forward to the day when there will not be rural land enough for every African and some will have to live permanently in urban areas. In some locations the government has built "hostels" for men in the town without wives. These are not unlike army barracks, and four men usually share a room.

At the opposite extreme are miserable shacktowns, lacking in amenities and even minimum sanitation. Only the searching African sunshine keeps these premises habitable. The buildings are put up hastily by contractors, or may be thrown together of odds and end by the Africans themselves. Most of the locations are neither so good as the best nor so bad as the worst. At Salisbury nearly half of all wage earners living in locations can be accommodated in decent houses or hostels. The rest live where they can, pending construction of more municipal housing.

Costs of construction would be reduced if Africans instead of Europeans were given the job. At Bulawayo one location is reserved for Africans who lease land for 10 to 25 years, and obtain a government loan with which to buy materials for houses they build themselves, according to standards set by the municipality. This is practicable for only those few families that have cut their tribal connections and intend to live permanently in the urban community. A proposal made in 1954 would permit Africans to buy house lots as freeholds in specified locations. This is frowned upon by many Europeans, who point out that the government would lose control of standards for construction and maintenance. Here enters the issue of urban land tenure, hitherto not a cause of racial friction in Southern Rhodesia.

TRANSPORT

Southern Rhodesia has no navigable waterways, it lies well inland, and most of the population lives on a high plateau. The first settlers had a route cleared for them as they trekked into the country, and every advance in economic life has rested on improved means of moving into, out of, and inside the region.

Railways

British authority extending to the Zambezi River was a dream of Cecil Rhodes of the Cape Colony. To further the hope a railway was projected northward (Fig. 1.) Skirting the unfriendly Transvaal Republic, it had reached Vryburg on the desert margin by 1890, when the Pioneer Column left the railhead for Mashonaland. Three years later railway construction was resumed. The line followed the edge of the desert for most of the 500 miles to the Rhodesian border, and in 1897 entered Bulawayo. It has remained the only direct rail connection with South Africa, and the section traversing Bechuanaland has always been operated as part

of the Rhodesian system. Port Elizabeth, the nearest South African port, is more than a thousand miles from midland Rhodesia. Persistent efforts to attract traffic, including an official pledge, bring some imports that way, but the rest, and all of the bulky and heavy minerals that constitute the basic Rhodesian exports, are shipped via the Indian Ocean port of Beira over a rail route only one-third as long.

Construction of that railway for 200 miles from Beira across the Low Veld of Portuguese Mozambique and up the abrupt escarpment of the Rhodesian Plateau was undertaken early and in spite of natural handicaps. The first section was in operation in 1893 and the line reached Umtali just over the border in 1898.

The harbor selected was the estuary of the Pungwe River, the only deep and safe anchorage for large ships between Lourenço Marques, 550 miles south, and Nacala, 300 miles north. The port was built on a narrow spit of sand between the sea and the mangrove-bordered river. Water was stored in cisterns or carried from five or six miles inland.

Until the rails were laid, some ox-teams were used for transport, but losses caused by sleeping sickness were so high that African porters were much employed instead. Malaria and its complications killed many of those who stayed in the area to carry loads or to build the railway. The first line had a 2-foot gauge, and nearly 50 miles were laid across the Pungwe Flats, which the river flooded every year, halting rail movements for weeks. Locomotives burned wood, and unroofed freight cars were used also for passengers, except on the weekly mail train. The line was reconstructed to include an embankment across the Flats that stood above high water except in very rainy years, a bridge at Beira, and a climb from Macequece in the foothills to Umtali, some 1,200 feet in 20 miles. By 1900 the gauge was widened to 3 feet 6 inches, already in use on the Rhodesian highland and throughout the Union of South Africa.

At the beginning of 1902 the line along the axis of the High Veld was completed, thereby connecting the eastern and western portals of Southern Rhodesia. It carries most of the passengers, as well as much freight (Fig. 46). The northward extension from Bulawayo reached Victoria Falls on the Zambezi in 1904. This was the pioneer European route of north-south transport in the interior of Middle Africa, and was looked upon as an important link in a prospective Cape-to-Cairo railway. It was deflected westward to reach the scenic waterfall and at the same time to cross the Zambezi at the narrow, cliffed gorge below it. Traversing the Wankie coalfield was incidental, because any route up to 200 miles farther east would have crossed a coal deposit.

Branches of the line between Bulawayo and Salisbury have been constructed as needed, nearly all of them to tap mines. The agricultural output has thus far not promised to repay extension of the rails. It was long expected that a direct line would link the Rhodesian Midlands with the heart of the Transvaal, and in 1929 a bridge was thrown across the wide Limpopo. Many Southern Rhodesians have feared that an influx of Africaners might overturn their British way of life, and the railway has never been built.

Meantime, congestion on the line to Beira delayed shipments, and in 1949 the Portuguese government took over operation of the Mozambique part of the line. Improvement in shipping followed, including new wharves for minerals and for oil, but both port and railway were still inadequate. In 1952 construction began at Bannockburn, near Shabani, to extend that branch line to Guija in Mozambique, terminus of a line from the seaport Lourenço Marques, which will thus be brought

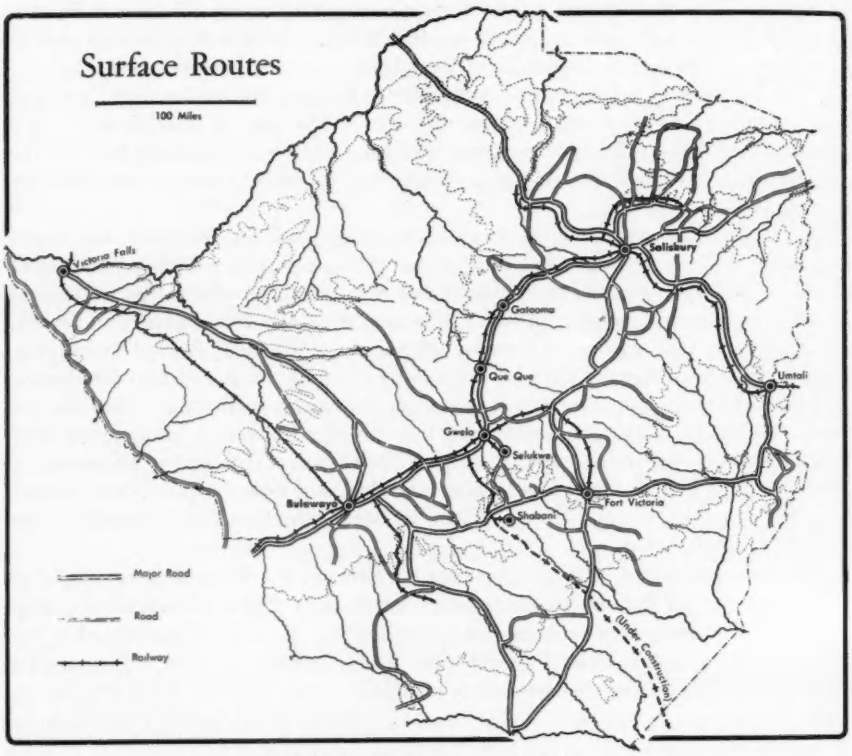


FIG. 46. Surface transportation lines.

within practicable distance of Southern Rhodesia. The railway will run mainly through Low Veld, and it will avoid territory of the Union. From the main line to the port the distance is about 500 miles. It will serve Matabeleland better than does the present line to Beira via Mashonaland (Fig. 1).

The next railway to be built is projected from the present terminus at Zawi, northwest of Salisbury, to Lusaka, capital of Northern Rhodesia. This shortcut from Mashonaland toward the Northern Rhodesian mines will expedite the haul of copper and other metals to Beira. It does not touch Wankie, but with only a little deviation it can be made to cross the coal formation near its eastern end.

The active extension of rails indicates that this part of Africa lacks the minimum network of heavy duty transport required by the mineral base of its economy. Ever since the war there has been a marked shortage of rolling stock, to the detriment of all business, but especially mining, in both the Rhodesias.

Roads

Although Southern Rhodesia depends on rails for volume transport between main centers and beyond the borders, most places are reached only by road. There are fewer than 1,300 miles of railway, compared to about 24,000 miles of rural roads and tracks (Fig. 46). The basic pattern of main roads supplements the rail lines.

FIG. 47. A characteristic low-level bridge. The cut in the valley wall makes the approach less precipitous than many.

Roads connect rail terminals, they lead to the principal points on the frontier that are not served by railways, and they act as branch lines from stations along the rails. There is also a road paralleling every rail right-of-way, perhaps crossing and re-crossing the line to keep to the smoothest terrain.

Until after World War I few roads had any sort of pavement, and 90 percent of the mileage at mid-century remained unsurfaced, except in places with loose gravel. Two-fifths of all roads are within Native Reserves, and many of them are mere tracks for crude carts and sleds. Dirt roads dry out quickly in the bright weather that usually follows a rain, but they become rutted and dusty, and are hard on motor vehicles. To facilitate motor traffic at minimum cost, 1,400 miles have

been laid with two narrow wheel-strips of concrete or tar-macadam. These serve light traffic adequately in all weather, even when they connect points of some importance. They are unsatisfactory where traffic is heavy enough to entail frequent meeting and passing. Therefore 1,000 miles of well-travelled roads have been surfaced with a 9-foot width of pavement—generally tar-macadam. Between principal towns another 300 miles have a tarmac surface wide enough for two lanes of traffic. Roads are constantly being improved.

FIG. 48. A motortruck fording the Mazoe River in the dry season. The dark line of water in mid-channel is only a few inches deep.

Stream crossings are critical places on routes. Tracks used only in the dry season may be followed across the sand of a dry channel at some risk of getting stuck. Some small streams that carry water all year may be crossed by a ford of concrete or stones that defines the road and provides a footing. During and for a time after rains fords are impassable; hence, main motorable roads are generally provided with bridges (Fig. 47). Most of these are one-track roadways ten or twenty feet above low water. They have no guard rails, and they are submerged during every hard rainstorm, but light rods at hub height indicate the safe depth of the water and the location of the roadway. Signs warn motorists not to attempt crossing when the rods are submerged. There are about 450 such bridges in the country, besides some 60 high-level bridges that are never submerged. Three of the latter are large engineering works: one carries road and rails across the Limpopo on the direct line from the High Veld of South Africa; one takes a road across the

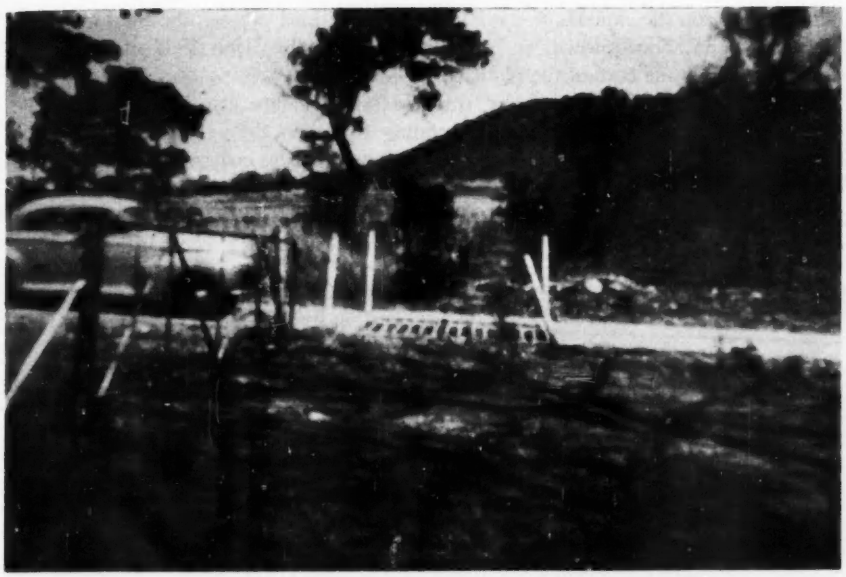


FIG. 49. A public road crossing a fence line. Motorcars pass through an opening paved as a cattle guard; the gate may be opened to permit animals to pass.

FIG. 50. An ox team of sixteen animals at the railway station of a country town (Banket).

Zambezi between the capitals of the Rhodesias; the third crosses the Sabi tributary of the Limpopo about midway in its course and ties the High Veld of the south-eastern border to the core of the plateau.

A few of the larger streams that traverse low veld are crossed by automobile ferries when their wide channels are running full. As they subside and become expanses of sand with here and there a pool or a trickle, coarse mats are thrown down on the sand to minimize the risk of getting stuck (Fig. 48).

Where roads leave territory infested with tsetse flies, all vehicles must stop to have the underparts sprayed. If the government is making a record, the traveller

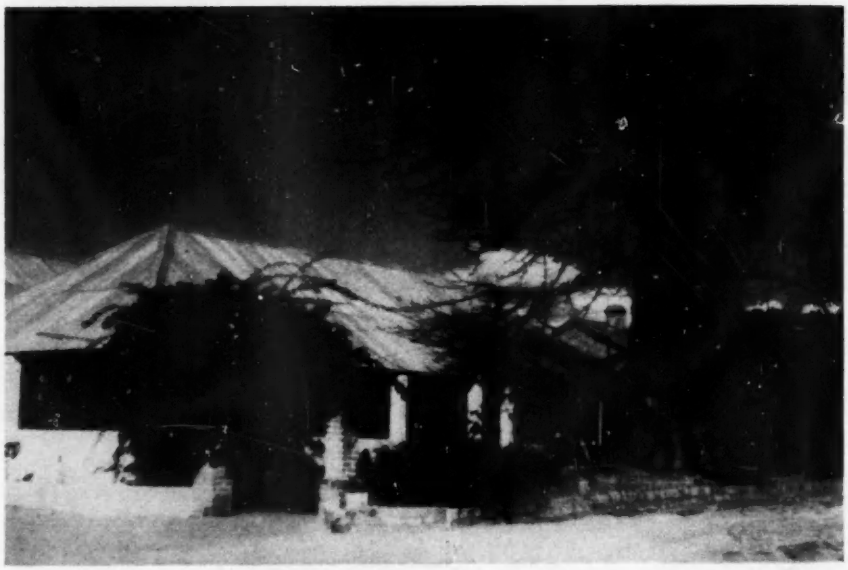


FIG. 51. The main building of a country hotel at Mtoko, the border station on the highway to Mozambique and Nyasaland. The construction—burnt brick walls, and corrugated iron roof incorporating a veranda—was standard for several decades. The shady bougainvillea vine is typical; the baobab tree, leafless in the dry season, is an unusual feature.

responsible for the vehicle fills out observations of wind and cloud, while the car is being searched to make a count of flies.

Livestock are often seen grazing along the roads. In the Native Reserves and sometimes in the European areas they are herded by men or boys, but European properties are generally fenced. If the holdings are large, the only internal fences surround fields in crops, and the cattle have the run of the rest. The fences along property lines give way to gates across the public roads (Fig. 49). For the motoring public an opening is paved with rails, which the cattle dare not cross. To let livestock pass, an ordinary gate may be opened.

Long teams of oxen or donkeys are common sights along the roads. The donkeys belong to Africans, the oxen to either Africans or Europeans (Fig. 50). If the motorway is surfaced, a dirt track runs alongside for draft animals.

Along vital roads in the less densely settled areas, no matter whether surfaced or not, there are road camps of a few huts at regular intervals, where maintenance crews live. Except in the driest parts of the Low Veld in the south and the Sandland in the northwest, each camp has a well where travellers can get water.

At railway stations and appropriate stopping places on principal roads there are country hotels (Fig. 51). Size and style vary, but there is a main building featuring the dining room, and including a lounge, an office, and usually a veranda. Rooms for clients may be incorporated, but are more likely to be one- and two-room huts facing a yard or scattered about it. The kitchen is a separate building. Where traffic is light, hotels are a day's journey apart, but there are simple tearooms in between where refreshments can be had (Fig. 52).

FIG. 52. A tearoom catering to the light travel on the road that runs east from Fort Victoria. The adobe walls and thatch roof represent a more primitive construction than that illustrated in Figure 51.

Public transport includes bus lines on 3,000 miles of highway that connect all centers with the railway system. A number of bus and truck services are operated by the Railway Company. Local lines may be privately owned. Some busses seen on the roads are chartered by mining and other firms to transport migrant labor.

The customary bus is a truck. The front seat accommodates the driver, who is

usually a European, and a favored passenger or two. Behind is a long first-class seat, in practice reserved for Europeans. Next come one or two second-class seats, occupied by Asians and those Africans who can afford it. The body of the truck is roofed, and the sides are heavy wire. Inside is a melange of freight, baggage, domestic animals and fowls, and African passengers. The top may accommodate more Africans, as well as passengers' bicycles. The driver has one or two African assistants to collect fares and handle freight.

Airways

Air routes cross the country, with Salisbury as the center. Local lines connect with Bulawayo, Gwelo, Que Que, Gatooma, Fort Victoria, and Umtali. Official corridors provide for crossing the borders at the rail and chief road exits. A major function of air transport appears to be communication between Southern Rhodesia and its African neighbors and, beyond them, Europe. The original airfield at Salisbury, occasionally rendered useless for some hours or days by torrential rains, is being relocated on a drier site.

Migratory Labor

A distinctive aspect of circulation is the unceasing movement of men, sometimes accompanied by their families, between their tribal homelands and jobs in European centers. The basic attraction that draws men out of the bush is high wages, and Southern Rhodesia is only a part of a pattern that ramifies throughout south central and southern Africa. Mining companies pay the most, especially the large units in the Union of South Africa and the Copperbelt of Northern Rhodesia, followed by manufacturing and construction. Even farmhands and domestic servants may be paid more in some districts than in others, depending on the location of shortages and surpluses of labor.

Until about 1925 migratory laborers made their hazardous way as best they could. They had to walk distances up to the 1,500 miles that separate densely peopled Nyasaland from the principal mining centers. Surfaced roads scarcely existed, food might not be available even for those who could pay for it, waterholes were irregularly spaced and in places far apart, and predatory animals roved at night, forcing the travellers to sleep on precarious platforms in trees (Fig. 53). Employers found they had to feed the arriving job applicants for days or even weeks before they were fit to work, after loss of weight caused by semi-starvation on the journey.

As roads were improved, hardships were lessened, although the many who walk still find the going rough. A good many take busses or trains, after walking from their homes to a main highway or a railway station. An increasing number ride bicycles; a man can save enough out of a year's wages to buy a sturdy machine. Several large employers provide motor transport for laborers under contract, and a few have recently been moving their prospective employees by air.

It has been estimated that nowadays, of all Nyasalanders on their way to distant

jobs, 5 percent take trains, 15–20 percent go by truck, and the rest (75–80 percent) walk. On return, with wages in pocket, the figures are 10, 25–30, and 60–65 percent.

The flow of migrant labor has come to be supervised and regulated by agreements between the governments concerned. Southern Rhodesia handles all its im-

FIG. 53. A "resthouse" in a tree, not far north of Beitbridge. Used by laborers walking to or from mines in the Union of South Africa.

migrants through a Rhodesia Native Labor Supply Commission, set up in 1950. The country absorbs the labor of considerable fractions of the total adult male population of neighboring political units:[18]

[18] Peter Scott, "Migrant Labor in Southern Rhodesia," *Geographical Review*, Vol. 44, (1954), p. 29; and *Central African Territories: Comparative Survey of Native Policy* (London: H. M. Stationery Office, 1951), p. 74.

from Nyasaland, one-fourth, totalling 80,500;
from Northern Rhodesia, one-sixth, totalling 45,500;
from Mozambique, one-tenth, totalling 72,100;
from Bechuanaland and other areas, an undetermined fraction totalling 4,400.

In all, about 200,000 laborers from adjacent territories are employed.

Ordinarily, these workmen are not allowed to remain in the country more than 24 months before going home for a period of tribal life, but if they have brought their wives and children, their stay may be extended indefinitely. In 1949 nearly 4,000 immigrant women and children held permits to live in Southern Rhodesia.

Men from the Native Reserves of Southern Rhodesia participate in the migrations in search of work. A study made in 1948 indicates that just over half the adult male population is absent at any one time. This figure, about 200,000, includes only 25,000 or 30,000 at work outside the country. In other words, about nine-tenths find jobs at mines, in towns, and on farms within easy reach of the numerous reserves interspersed with European settlements. Men who do cross the political boundary usually go from parts of the Middle Veld that are very rugged or very sandy, or from the few High Veld areas where population is likewise sparse and jobs are scarce.

Both local men and immigrants from neighboring territories who seek work but have no contracts providing transport may avail themselves of free shelters and of depots where food may be bought—conveniences set up by the Rhodesian government along 4,000 miles of main-travelled labor routes. They may also take passage on government busses or trucks that operate on 2,500 miles. After working nine months or more in the country, the men may use the same facilities in returning home.

In spite of inducements, the supply of labor appears to be dwindling. More unskilled laborers are finding jobs either in their home communities or in the very large mining camps and cities. In Southern Rhodesia an increasing proportion of jobs require skills rarely possessed by migrants. Evidently the country must prepare to do more work with fewer workers. This means substituting machines for men wherever feasible, and paying wages that will encourage Africans to acquire skills and induce the trained men to stay in one place. Incidentally, if labor is paid enough to increase mass purchase of consumer goods, the burgeoning local factories will benefit. "Cheap labour is an economic anachronism."[19]

AMENITIES

Africa is unfavorably known for prevalence of diseases labelled "tropical," but Southern Rhodesia is considerably less plagued than most areas, thanks to its latitude near the edge of the tropics and the high altitude of much of it. The present stage of occupance began shortly before basic discoveries about the cause and spread of tropical diseases were made. Sanitation, medicine, and nutrition have been the three chief weapons for fighting the diseases that occur.

[19] Southern Rhodesia, Development Coordinating Commission, *First Interim Report* (Salisbury, 1948), p. 10.

Health

At the outset malaria was virulent on the Low Veld, and it was common everywhere except at the highest elevations in the northeast. There were and are more cases during the rains than in the dry season. For a generation after mosquitoes were found to carry malaria, few took precautions to avoid it, and today it remains the disease that kills the largest number, besides being the most potent cause of chronic anemia and low vitality. In the larger European centers mosquitoes are kept in check and in the dry season are rather rare. In rural areas farm practices, especially the draining of bogs, have reduced illness among Europeans, but it is still widespread among Africans living on European holdings and in Native Reserves. Recently the government has undertaken to spray with insecticide, twice or thrice during the rainy season, all habitations in specified areas. Where that has been done, malaria is lessened and incidentally the vermin in the thatching of native buildings is much diminished.

An ailment that may cause death, but does its chief damage in producing widespread ill health, is bilharzia, a blood disease transmitted by certain fresh-water snails. In hot weather, the temptation to wash or bathe in any cool body of water is rarely resisted by Africans. The government crews that spray mosquito larvae during the rains turn to reducing the snails during low water by chemical treatment of streams. There is some prospect that specifics for curing both malaria and bilharzia may soon be found.

A third disease that lowers vitality is hookworm, commonplace among Africans because of their general habit of going barefoot, but less prevalent than in many African lands. Other diseases are leprosy and, among miners, silicosis. The southern limit of yellow fever is believed to be the Low Veld north of the Zambezi Escarpment.

Illness is directly attacked by a medical organization that is one of the government's chief responsibilities. Each of the larger centers maintains a hospital for Europeans, and in the European quarters of the towns thoroughgoing sanitary measures are sedulously maintained.

For Africans the central government operates a system of hospitals with which are associated medical facilities furnished by mining companies, the railway, Christian missions, and local authorities. Their range is as follows:[20]

	Number	*Beds*
Government general hospitals	13	1,126
Mental hospitals	1	580
Leprosy hospitals	2	1,680
Maternity hospitals	2	243
Tuberculosis hospitals	2	218
Government clinics	87	3,763
Medical missions	47	1,015
Local authority hospitals	6	361
Mine hospitals	9	820

[20] *The African in Southern Rhodesia: Number two—Health* (Salisbury, 1952), p. 4.

The clinics are cottage-hospitals. Altogether there are about 10,000 beds for African patients, who numbered 250,000 in 1950. In the same year 3,500,000 outpatients, who do not occupy beds, were treated. General hospitals being constructed over a period of a few years at the two chief cities will add 2,400 beds to the total.

Apart from diseases, many Africans are undernourished. Their diet is ill-balanced, depending heavily on starchy tubers and grains. Crop shortages due to adverse weather occur. Wage earners are tempted to save on food in order to buy other things, or they may unwittingly subsist on an unbalanced diet. Increasing the output of wage-earners is bound up with improvement in the general level of health and nutrition.

It has been found that an unbalanced diet increases the susceptibility of Europeans to tropical diseases; this must be true also of Africans. In the early decades many European men depended on the restricted menus served by African houseboys with meager training as cooks. Family life is now general, and food is more varied, although within the range of the British tradition. Neither tropical foods nor Afrikaner cooking are in evidence, but breaks for tea at eleven and five o'clock are fixed rituals.

Housing

A good many Africans in rural areas now live in rectangular houses having one or two rooms, although cylindrical huts are also numerous. Some 67 percent of all families in reserves live in adobe or brick habitations. The rest make do with traditional mud-plastered walls and thatch roofs. Housing in towns varies considerably, being both better and worse than the rural standard. It ranges from neat and substantial structures of concrete and asbestos to shacks of scrap wood and metal.

European pioneers lived in "wattle-and-daub" huts made for them by the local Africans. Stakes cut from the bush, driven into the ground, and smeared with adobe clay made the walls, and poles tied together with bark supported a thatch roof of tall native grass.

The next step was to erect a house of several rooms, using bricks burnt on the place or the edge of a townsite, topped with a roof of corrugated iron brought out from England. It was likely to have a veranda, but otherwise it imitated the British model in having several small rooms with little windows—suitable in the cool, moist British Isles but not in hot, breeze-swept Rhodesia. Moreover, an iron roof makes a house cold on winter nights and hot on sunshiny days at all seasons. Lots in the towns were small, and houses everywhere were placed without reference to the almost continuous breeze, a ready to hand air-conditioner for reducing indoor temperatures.

Of late an architecture suited to the climate has been widely adopted. It emphasizes broad verandas on two or more sides, large windows, and asbestos-cement roofs. Rooms are large and the furniture is of simple design made by hand from local cabinet woods.

Recreation

Southern Rhodesia possesses a number of tourist attractions, visited by a few Asians and Africans, but mainly by Europeans. Besides the wild scenery (Fig. 7) of the Matopos with its cave drawings and its burial place for national figures, and the mystifying zimbabwes (Fig. 12), the rugged mountains of the east provide recreational centers at elevations high enough to be health resorts. Umtali is the center for these districts and has itself become known as a pleasant and healthful residence for people who have retired from posts in other parts of the British Empire, as well as Southern Rhodesia. Some public buildings show Portuguese architectural ornamentation. Asians are more numerous than elsewhere in the country.

FIG. 54. Aloes, with a background of cycads, in the Aloe National Park some miles east of Salisbury.

Sixty miles to the north is a national park, Inyanga, where mountain scenery, crisp air, unexplained ruins of an earlier society, and green herbage always make a varied landscape. A dozen miles southeast of Umtali are the Vumba Mountains. Their mists and breezy passes remind the British-born of Scotland or North England. About 120 miles south is the Silinda Forest, 1,600 mountainous acres of relict rain forest, including "mahogany" trees up to 200 feet high. Called by the Africans Chirinda, meaning place of refuge, its value to Europeans is recreational.

A few miles east of Salisbury, on suitably rough and rocky terrain, is a garden of aloes (*Aloe* spp.), said to contain specimens of practically every variety of aloe native to other continents as well as to Africa (Fig. 54). The collection was made by a private individual, and has become a national park.

Perhaps the most famous African tourist attraction south of Egypt is the Victoria Falls, "the smoke that thunders," where the boundary river Zambezi drops 304 feet into a recessed canyon. The only nearby hotel, built and run by the Railway Company, faces an earlier defile through which the river plunges below the falls, and has much the quality of the Canadian Pacific hotels in tourist centers of North America.

For holidays outside their country, those who can afford it may spend a part of the hot season at the seashore of Natal. Even Beira has of late had a small resort business, thanks to its nearness. Many people feel the need of an occasional letdown from the bracing weather of the High Veld. It is now generally agreed, however, that the climate of the plateau is not inimical to permanent habitation by generation after generation of Europeans.

Religion

The first Europeans to settle down among the Animists of south central Africa were Christian missionaries, two or three of whom arrived more than thirty years before the trek of the Pioneer Column. From that date, missionaries sent out by an increasing number of sects have worked uninterruptedly among the tribes, and mission centers cover the country. They are still supported in part by contributions from older English-speaking countries. A considerable number of Africans are professing Christians.

At the mines and especially in the towns, Europeans held religious meetings from the first, and soon built houses of worship for separate use by the several denominations represented in the population. Most church edifices are modest in size, since the European population divides its religious allegiance, in accord with the toleration customary in areas ruled by Britain (Fig. 44).

Education

Schools for the three communities are entirely separate.

For Europeans, a better than average schooling is important, if they are to maintain leadership among the Africans, who are constantly extending and improving their own training. The desired quality is hard to achieve. First, local schools cannot be provided for all the scattered population of the rural and mining districts (in 1951 there were only a few more than 25,000 pupils in all). Second, the climate favors outdoor life rather than devotion to books.

In 1951 there were altogether 134 schools for Europeans, of which 11 were private, 22 received government aid, and the rest were operated by the central government. One was a correspondence school, to aid rural parents in preparing their young children for the boarding schools they have to attend after the first years. Since 1937, tuition has been free in government schools. Most secondary schools, and those specializing in technical or commercial curricula, are in or within 25 miles of one or the other district centers. Nearly all the schools are modelled after the British tradition, although a small agricultural school opened in 1950 was an innovation. Until now, all higher education has been obtained in the Union of South

Africa or in Britain. Appropriately, there are three Rhodes scholarships to Oxford, and other funds are available to cover part of the expense of attending distant universities.

In 1953 the cornerstone of a university was laid at Salisbury, where 458 acres have been set aside. Originally intended exclusively for Europeans, pressure from the northern members of the Federation of Rhodesia and Nyasaland has broadened its clientele to include qualified inhabitants of the federal union regardless of race. All will attend the same classes, but Europeans, Africans, and perhaps Asians, will live in separate dormitories equidistant from the center of the institution.

FIG. 55. A lower school, commonly called a kraal school, at a headman's village in a Native Reserve. The castle hill in the background may once have been used as a defense point.

There are 18 lower schools for colored and Indian children.

Schools for Africans were originally run by the missions, interested in training African Christian leaders. Hence the course of study laid stress on becoming conversant with the Bible and, by extension, with the printed word. Teaching followed the British academic tradition. Ever since, increasing enrollment indicates that the demand for book-learning has intensified.[21]

[21] A comment made a generation ago still holds true: "The passion of the native for book learning is . . . remarkable. . . . Somehow he has the idea that the secret of the white man's superiority is bound up with that power to read and write—it is to be found in those books of which he has such a number. The mere possession of books has a fascination, . . ." Ethel Tawse Jollie, *The Real Rhodesia* (London: Hutchinson, 1924), p. 270.

In 1950 there were 238,000 pupils registered in 2,300 African schools, with an average attendance of 190,000. All but two percent attended schools operated by missions, to which the government began to allot financial aid at the beginning of the century. The curriculum has been modified to put increasing emphasis on practical training, especially in agriculture, the vocation to which most of the pupils will devote their lives. All but a few of the African schools are scattered about the Native Reserves. Generally called "kraal" schools, they are usually one-room thatched huts of adobe or sun-dried brick, put up by members of the community (Fig. 55). Some have two or three buildings and enroll day pupils from homes as much as four miles away. Academic subjects and also agriculture and mechanics are taught.

FIG. 56. A central or boarding school, attended by children who have completed the course at a kraal school.

Children who have finished their course at the kraal schools may attend central primary (boarding) schools (Fig. 56) of which there are eighty. Each institution has 100 acres of land where the pupils learn agricultural practices while growing a large part of their food.

During the past decade primary schools have been built by the government in the new housing villages (locations) near the larger cities. They put less emphasis on agriculture and more on trades than do the rural schools. The buildings are generally of stuccoed brick with asbestos roofs. In the evenings there are classes for adults.

Schools more advanced than the primary grades are not numerous. There are 18 teacher-training centers with 1,000 pupils, five special schools for agriculture, trades, and domestic science, and five secondary schools. All are located near one or another of the principal towns. Teaching of Africans is in the hands of 350 Europeans and 6,900 Africans.

Clothing

Europeans wear clothing adapted from English models to the life they lead. Indoors it is informal by British standards—a concession to novel frontier conditions on a low-altitude highland. Women may wear tweeds in the cool season, cottons when it is hot. For men who work outdoors the khaki "bush shirt" is generally worn, with either shorts or trousers, varying with the season and with personal preference. A few who must be out in the sun all day stick to sun helmets, but most men and all women wear soft felt hats. Sportswear is adapted to the game being played.

The dress of Africans more strikingly attests the transitional stage of life in Southern Rhodesia, conforming to European standards to the degree of contact with Europeans. Doctors and nurses in hospitals wear regulation uniforms. House servants and waiters in hotels wear a shirt, long trousers, and shoes. Nearly all workmen go barefoot; they may wear either trousers or shorts, and almost invariably they wear a shirt, even though it be in rags. At work in the fields, men may discard the shirt. Many individuals wear outlandish garments, ranging from extreme cuts of clothing and plumed hats, affected by young bloods in the towns, to heavy overcoats (evidently much prized) worn on the hottest days, and ragged castoffs of all kinds equally unsuited to the time or the place. Even small boys wear a clout, and only the infants in arms are unclad.

Women generally wear dresses modelled on European modes as to length, and in the towns as to style as well. But even the best dressed young women may go barefoot. Mothers have retained the habit of carrying their babies on their backs, swaddled in a scarf, but many women have abandoned headloads unless they are laden with more than they can carry in their hands.

ALLOCATION OF THE LAND

The indigenes living between the Limpopo and the Zambezi had no strong interest in minerals in 1890, when the first wave of European immigrants came seeking gold. The Africans' concern was for the land, from which they procured their food, clothing, and shelter. They hoed the ground to grow crops and pastured livestock on the savanna. Cattle held for their owners the special virtue of serving as the symbol and pledge of family continuity.[22]

The Chartered Company that sponsored the Pioneer Column held rights of settlement from the paramount chief of the region for mining only. Miners had been in the country more than a year when the same paramount chief gave to a German

[22] Because of the custom of *lobolo*, often translated as "bride price," but better understood as "child price."

national a concession to farm in Mashonaland—rights which the Chartered Company later purchased.

Another year passed before immigrants seeking farmland arrived. The vanguard came from the Africaner states to the south and included families of both British and Dutch extraction. They passed over the Low and Middle Veld, to settle on the high plateau (Fig. 14). Some located between the Sabi Valley and the Mozambique boundary. They had the advantages of soils derived from sediments, including limestone, abundant rainfall (40 inches or more), and, on the higher slopes, short mountain grass kept green practically the year round by mists. Others spread out on the watershed halfway between the Company's forts at Victoria and Salisbury. There the rainfall averages about 30 inches (Fig. 3) and the soil is sandy—a combination that permits both crop growing and livestock rearing. Neither of these initial farming areas was near gold mines, and both found that the only product they could sell for cash was cattle, which could take themselves to distant markets. Later immigrants were likely to pick the heavier soil for farms because it was unoccupied by Africans. Incidentally, it was relatively productive and, being associated with gold-bearing reefs, had the advantage of a market close at hand in the mining camps.

The estimated 400,000 Africans in the area when Europeans arrived in numbers were unevenly distributed. The Low Veld was thinly peopled. Semi-nomadic folk roamed over the drier western half of the High Veld. In the moister east, raids had crowded small sedentary farming groups into rugged or remote refuge districts of the High and Middle Veld, which could produce only a meager living for so many. When the swift spread of prospectors and the arrival of European farmers and ranchers put a stop to raiding, many tribes left their fastnesses for the open plateau. They generally chose the sandy land on the widespread granite because they could work the light soil with their hand tools.

In the flux of these movements, allocation of the land between Africans and Europeans became necessary. A Land Commission appointed for the purpose attempted to set aside two large "Native Reserves." This scheme reflected the prevailing view of a two-part territory—Mashonaland and Matabeleland. It took no account of the many Mashona tribes, nor of the intermingling of European and African landholdings throughout both districts. Several redistributions of land have since been made as both the African and European communities have grown and as land use has altered.

By 1914 the African population had doubled, and more than 100 Native Reserves had been set aside. At mid-century the population had doubled again.[23]

[23] No census has ever been taken of the African population of Southern Rhodesia, but the Native Commissioner estimates the number from time to time. In December 1947 the figure was set at 1,630,858. During the ensuing months a careful sampling was made by a team interested in finding a statistical procedure which would hold errors to a small percentage. The figure they arrived at for August 1948 was 1,619,000. This suggests that careful estimates by the European officers in touch with African affairs are reliable.

The statistics collected by the team of investigators led to a prediction that the African population will continue to double every twenty-five years.

There are 94 Reserves (Fig. 6) situated in all parts of the country, running the gamut of its natural environment, and ranging widely in area and population.

Concurrently with setting aside Native Reserves, land was procured by Europeans, generally as freeholds. For years a typical estate in Matabeleland comprised 6,500 acres, and in moister Mashonaland about half that amount. The average has been somewhat reduced, but holdings of 10,000 to 30,000 acres are not uncommon.

The Chartered Company itself held out large tracts for experimental agriculture. During the first fifteen years, it assumed that farmers and ranchers would take up land on the heavier and more productive soil associated with gold-bearing reefs, where they also had the advantage of a market close at hand. An influx of farmers after the Boer War found that much of the best land had already been taken up and was being held speculatively at prices beyond the reach of the immigrants.

Not until 1907, when the Company achieved its first balanced budget, did it adopt a policy that encouraged farming by Europeans. A Land Department was then set up and attractions of the country were presented to the British public. The company required a quit-rent from all who obtained land, in addition to the purchase price. In Mashonaland, which was rainy enough for crops, the price was 1s. 6d. per morgen; in Matabeleland, generally suited to livestock only, it was 3s.[24] This surprising inversion of the usual relation of land values grew out of two facts: the cattle could walk to market, and the natural pasture had been heavily grazed by Matabele stock, thus providing forage more edible than the rank grasses in most of Mashonaland, which for decades had flourished ungrazed, except sporadically by wild animals.

By 1914 half the land within twenty-five miles of a railway line was in private hands. Of the entire High Veld a third had been sold. Many purchasers had taken up more land than they were able to use for years. There still are considerable tracts of natural bush near the rails, and in places alongside the right-of-way.

During the years of large land sales the settlers challenged the Company's assumption that it owned the land, as distinct from administering the country. In 1917 the Privy Council sitting in London decided that the land did not belong to the Company, because no subject of the Crown could acquire land by conquest. At the same time the blanket claims of the inhabitants, whether European or African, were likewise ruled out. All land not already alienated to individuals or reserved for groups was adjudged Crown property.

African and European landholdings form a crazy-quilt pattern, but on the Low and Middle Veld European undertakings are specialized and few, being mainly livestock ranches and sugar or tea plantations. Besides tribes on Native Reserves, a good many Africans live as squatters on the Crown lands, which are most extensive in the Low Veld. In places their cattle have increasingly became instruments of severe erosion on river banks, and their only crop, millet, varies with the unreliable rains from abundant to failure. After 1950 the government undertook to resettle

[24] One morgen equals 2.17 acres.

many of these families in areas where they would have security of tenure and instruction in wise use of their soil.

The acreage of the High Veld is divided about half-and-half, although European holdings exceed the Native Reserves in total area. The intermingling of these contrasting communities brings them into close association—an arrangement that

TABLE I

LAND ALLOCATIONS*

Population classification	Square miles		Population, 1951
	Allocated	Alienated	
European, including Asian and Colored (mostly freeholds)	75,910	55,500	146,300
Africans in European areas			259,741
African	50,701		1,755,613
Native Reserves		32,532	1,205,808
Native communal reserves		5,888	90,951
Native purchase reserves (individual freeholds)		12,281	129,252
Forest reserves	1,543	1,543	4,290
Unassigned	22,170		65,571
Held for Europeans		1,775	?
Held for Africans		3,432	?
Held for game reserves		8,000 (est.)	?
Total	150,333	120,951	

* Figures on land are taken from Conference on Closer Association in Central Africa, *Comparative Survey of Native Policy in Southern Rhodesia, et al.* (London, 1951), p. 40. Figures on population are taken from *Southern Rhodesia: Facts and Figures for the Immigrant* (Salisbury, 1952), p. 3, and *The African in Southern Rhodesia, Number Three—Agriculture* (Salisbury, 1952), p. 2.

has suited Europeans, both farmers and miners, because it insures a source of labor not far away. A statement made during the early days presents the attitude frankly:

> The policy . . . adopted by the Company, and which commends itself to all on the spot, is to leave the Matabele kraals so far as is possible where they were. They will thus be scattered among the farms of the white men, as in Mashonaland, where the system is working well; native labour will be readily procurable, the Kaffirs [Africans] will soon attain such civilisation as is possible to them, and moreover, they will be under our immediate supervision. . . . To set these savages apart in reserves would be to indefinitely retard their civilisation. Rich in cattle and mealie [maize] crops they would refuse to labour for us, and would pass their lives in indolence; they would be outside our control, and consequently murder and witchcraft would flourish as of old; while, gathered together in numbers at periodical beer drinkings, the young men would talk big, scheme for war, and hatch all manner of mischief.[25]

[25] E. F. Knight, *Rhodesia of Today* (London, 1895), pp. 15–16.

Southern Rhodesian land allocations today are the product of many years of trial and error; the land is divided into three main classes: that assigned to Europeans, that assigned to Africans, and unassigned. A large fraction of the unassigned area is in the Low Veld, the remainder being in the sandy Middle Veld, or on still higher lands infested by tsetse flies. The fly-belt is being slowly pushed back by cutting brush and killing wild animals that harbor the insects, after which Africans are settled on the reclaimed land. Currently 2,500 head of game animals are being shot every month, in a move to make farm land available to the upsurging African population, an evidence that Southern Rhodesia has come face to face with the most urgent problem in Africa—scarcity of land. Table I breaks down the land allocation and presents population figures as of 1951.

Presumably most of the unassigned land not otherwise committed will be allocated to Africans. If this total of 8,972 square miles is added to the land already earmarked, they will eventually have 63,105 square miles, compared to the Europeans' 77,665. Adding the Africans who make their entire living in European areas to the other communities there, 406,000 persons can draw on 77,655 square miles, compared to 1,516,000 who can draw on 63,105 square miles.

AFRICAN USE OF THE LAND

Under African tribal regimes, most of the land was used intermittently as cattle range, and the scattered tilled plots were shifted to fresh soil after two or three years. The all-purpose farm tool was the hoe, suited to the light soils on granite that spread over most of the region. The grass was burnt during each dry season, to clear the ground for the tender forage that heralded the rains, including a bright green, broadleaf herb common in old fields. Land use and recuperation were in balance, except for destructive farming in some easily fortified districts, into which people and cattle had crowded to escape from raiding tribes.

Catastrophes that reduced pressure on the land were frequent. Epidemic diseases caused the death of large numbers of people and decimated the herds of cattle. Clouds of locusts flew in from the north and stripped bare wide belts of vegetation.[26]

Deterioration

The arrival of Europeans was followed by progressive deterioration of the soil. The death rate of both African people and their cattle was sharply reduced, thanks to stoppage of tribal warfare and raids, introduction of medical and veterinary services, and attention to sanitation. The rapidly increasing population needed additional land for crops and livestock, but before long expansion was checked in many places by holdings that Europeans had already carved out of the unoccupied domain for themselves.

As pressure on the available land rose, Africans replanted the same plots until the soil gave out and returned to them a few years later—before they had time to

[26] Unpredictable swarms of locusts still occasionally defoliate farms and ranges that happen to lie in their path. For a vivid description see Doris Lessing, "A Mild Attack of Locusts," *The New Yorker*, Vol. 31 (February 26, 1955), pp. 75–83.

recover their fertility. In order to plant more acreage, they substituted ox-drawn plows for hoes, a practice that reduced the output per planted acre and often started sheet-wash and gulleying.

> The sale of ploughs . . . superseded the old hoe-cultivation of man and wife. Many of the Natives who bought the ploughs, ploughed more land than they could keep in good heart, so as to get *money* from the sale of surplus grain, which the industries needed to feed the labour recruited from the kraals. And when the land lost heart, so did the peasant, who often ended by looking for a "job," leaving his wife to cope as best she could with her hungry gardens, and sometimes hungry children.[27]

The additional cattle overgrazed the savanna, and in places destroyed the grass

FIG. 57. An impoverished village on land under traditional shifting cultivation, but given inadequate rest intervals between periods of use.

cover. Trails made by the livestock to reach water and trampling in the vicinity of the waterholes started erosion. The number of cattle owned by Africans rose from an estimated 25,000 after the rinderpest epidemic of 1896 to more than a million in 1940. Many Africans also keep a few goats, which eat every plant they can reach and cut up the ground with their sharp hoofs.

By 1925 deterioration of the soil was so marked that the newly autonomous colony undertook its rehabilitation. For Africans, soil conservation entails a revolution in farm procedure and in social outlook—nothing short of substituting individual tenure for communal allotments and a cash economy for one based on cattle. A program designed to bring the change about has been formulated in law, but it is

[27] Charles Bullock, *Mashona and Matabele* (Cape Town, 1950) p. 221.

being put into operation by persuasion except in extreme cases, and African farmers have been slow to make so sweeping an alteration in their economic and social life. After twenty-five years three-fifths adhere to their traditional agricultural practices and much of the land is still worsening (Fig. 57).

Rehabilitation

The first requirement for improved land use is individual responsibility for particular pieces of land. Setting aside an area where natives can purchase freeholds

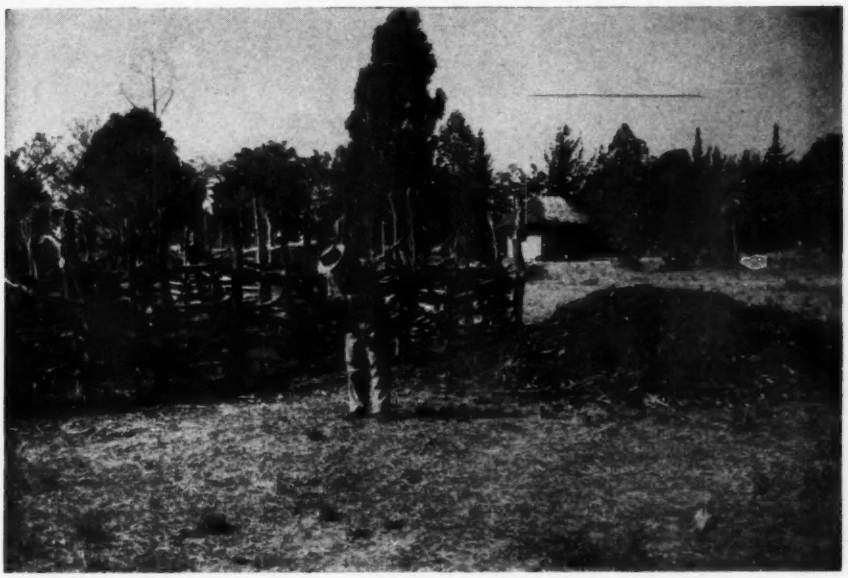


FIG. 58. A village in which improved farming has been inaugurated. The cattle are confined to the kraal (corral) at night, and the bedding is heaped nearby, to make compost for enriching the cropland.

averaging 200 acres, which they then operate, provides a means of substituting individual for communal ownership for those who are ready to forsake the tribal organization. Four thousand farms, totalling 800,000 acres, have been taken up in this way.

On the Native Reserves the land remains community property, but a novel mode of using it is being introduced by the government. It is assembled into large blocks for efficient subdivision, and each family is guaranteed tenure so long as it manages its holding properly. Some 18,750 square miles have been thus "centralized" and the authorities are actively pushing the changeover.

It has been found that an average family can cultivate six acres of cropland, and that amount will yield a living on selected soil in the rainier two-thirds of the

country, provided it is adequately manured. Six cattle, if brought into the farmyard kraal at night (Fig. 58), will provide the requisite fertilizer. To support its livestock the family is allowed 60 acres of grazing land in the rainier east, 80 acres in the Midlands, and 100 or more in the drier west. The savanna is grazed (Fig. 59) while crops are maturing; after harvest the cattle are turned onto the fields, giving the pasture land a few weeks' rest, when the grass is least edible. The six-acre unit of cropland will not support a family in the region of low rainfall, but its output is used to supplement the main reliance of that area—livestock.

FIG. 59. Cattle on rich grassland of a Native Reserve, in a part of the country having adequate rainfall for crops as well as livestock.

By 1940 it was apparent that cropland could nowhere be made available or kept in good condition until the inhabitants of the Reserves reduced the number of their cattle to the carrying capacity of the natural grass and available water. This would entail changes in the basic African custom of *lobolo,* by stressing quality rather than numbers, and introducing the practice of selling animals in excess of the ability of the land to support them. A law was passed, making destocking compulsory, but nearly everywhere persuasion and instruction by the government agents have brought the cattle owners around, without resort to the law. Provision has been made to facilitate the marketing of surplus animals, and in the process the herds are culled, so that the least desirable beasts are sold. A "camp" of high-grade bulls is available in each district for improving the quality of native herds as producers of meat and milk. In about a decade the number was reduced to the desired figure (677,000).

Traditional practice is tenacious, however, and during the past few years the cattle population has again been increasing.

Operation of the new farming system depends on the example set by Agricultural Demonstrators, Africans who have studied at one of the two agricultural schools. Each one cultivates two acres himself to serve as a model, besides guiding the group to which he is assigned. Cooperating farmers are given recognition at three levels, the highest being "master farmers," of which there were 1,665 in 1950. Just under 40 percent of all farmers in the country qualify in one of the three groups.

Crops on the progressive farms are chosen with careful reference to local conditions, and rotation is the rule. Three rainfall units are distinguished by the government for suitable rotations:[28]

In the moist east:	maize plus manure from compost
	maize
	a legume, such as peanuts, velvet beans, or sunhemp
	millet, usually eleusine, or cotton
In the midlands:	maize plus manure from compost
	millet, usually durra
	a legume, perhaps plowed under as green manure
	millet, usually eleusine
In the semiarid west:	durra plus manure from compost
	durra
	a legume plowed under
	millet, usually pennisetum

In 1950 the two most advanced farmer groups produced an average 7.9 bags of grain per acre, compared to 1.5 bags on ordinary communal holdings. Cotton is the only non-edible crop; it is sold to local textile mills, and Africans raised 63 percent of the country's 1950 output. In addition to providing their own subsistence, African farms marketed 46 percent of the maize sold, a like share of the meat, 98 percent of the small grains, and 83 percent of the peanuts.

Beginning during World War II, marketing boards have been set up by the government to aid Africans in selling their surplus crops and livestock. The grain is stored in granaries identical with those traditionally in use (Fig. 13). The thatch insulates the grain but hastens infestation with weevils and other insects, and the walls are thin and porous. The insects and their products, including indigestible integument, are ground with the grain in the wooden mortars that stand in every village. The thump of pestle against mortar is one of the most characteristic sounds of Africa.

The Native Reserves

Many Reserves are densely peopled, rated by their productivity. All day long the roads are animated with processions and groups of people on foot, many of the

[28] The threefold subdivision is replacing the distinction between Mashonaland and Matabeleland, as the tribal contrast has given way to critical differences in the evolving economy. Farming types, varying with rainfall, are paralleled by intensification of mining and manufacturing in the Midlands.

women bearing head loads. Near a center, such as a trading post, a mission, or a government school, the numbers increase. Vehicles range from sledges dragged through the dust or mud, to pack donkeys, ox-carts with solid wheels, bicycles, motor trucks, and even motor cars (Figs. 60, 61)—the motor vehicles often operated but rarely owned by Africans.

A trading post is likely to be at a crossroads or a fork. It centers on a row of stores (Fig. 62) which stock a wide range of goods—cloths, household wares, hardware, gewgaws, and foodstuffs not locally grown. One or two carry large lines of miscellaneous goods, including gasoline in a tank pumped by hand. These

FIG. 60. A sledge, only half laden, hauled by six oxen driven by a man and led by a boy. The soil alongside the road is being cut up by the runners of the sledge.

may be branches of large firms, engaged in buying products of the Africans as well as supplying their wants.

Often a Christian mission with its school is nearby. The pupils may live in the mission, to bring them into contact with the European mode of life as well as its learning. A government clinic or even a hospital may be built in the vicinity. These public and semi-public buildings are likely to be constructed of burnt brick.

The people live in villages convenient to their land (Fig. 15). A few still occupy low castle hills, although they are no longer defended. At one time many bush villages were transplanted to the roads by government authorities, chiefly to simplify the business of medical service, sanitation, and taxation. As roads have become more heavily travelled, villages are being withdrawn to relative safety from motor cars. The dwellings may be the traditional round huts of mud-daubed

FIG. 61. Three forms of contemporary transport: ox-cart with solid wheels, bicycle, and motorcar.

poles, surmounted by thatching, but at least some are larger, rectangular, and laid up with sun-dried brick. The headman, the teacher, and the demonstrator of farm practices may have houses with two to four rooms and some European furniture. Many villages have a local elementary school, housed in a building w. ch serves also as a community center. Granaries for storing crops may be more numerous than the houses.

FIG. 62. The stores at the principal trading post of a Native Reserve.

As a rule, the boundary between a Native Reserve and a European area is marked by a difference in intensity of land-use. Trees are likely to have been cut from the Reserve, a high percentage of the land has been recently under cultivation, vegetation is cropped close during the dry season, the herds are unfenced, and often in the charge of a boy. In contrast, the European freehold displays fields that are well-kept and planted to crops yielding a high return, cattle in ample fenced pastures, and stands of the natural small bush.

The contrast is accentuated where a Native Reserve has been bounded by the line of contact between buff or gray sands long ago selected by Africans equipped only with hoes, and chocolate or dark red clay soils, either bearing their rather dense natural stands of trees, or turned into productive European pastures or fields. Such coincidence of land use with soils makes the sharpest contrast to be seen in the rural landscape (Fig. 20).

EUROPEAN USE OF FARM LAND

European land occupance has been selected in several ways. It is largely confined to the High Veld, the backbone of which is the watershed of low relief between the Limpopo and the Zambezi. This watershed is followed for long distances by the railway and the main highway which thereby minimize bridging streams and cutting through hills (Fig. 46). The coincidence is faithful from the western border to the Midlands, and from Salisbury for miles eastward.

Elsewhere there is deviation, most marked in the Midlands. In that district an almost continuous string of gold workings attracted the first colonists, and the rails were laid to connect principal mining camps. The fertile soil associated with gold reefs was unoccupied, and the combination of minerals and farm land warranted the cost of bridging streams at distances up to 100 miles from the watershed where they rise. Toward the eastern border there is little gold and not much clay soil. There the rails descend along river valleys in preparation for the plunge off the plateau to the Mozambique lowland plain.

Most of the branch lines of rails have been built to mines, including chrome and asbestos, as well as gold, and a comparison of the maps of soils, mines, and railways proves more than an accidental relation between them.

All the land along the railways is in European hands, except for a few miles in the straightaway of the nearly worthless Middle Veld, where a sparsely populated Native Reserve is crossed by the line reaching out to the Wankie coal field and the Victoria Falls. In a number of places Native Reserves lie within twenty-five miles of a railway—the distance considered favorable for marketing farm products.

For decades Africans and Europeans alike contributed to impairment of their joint habitat. As early as 1925 the need for contour plowing was clear, but only since World War II have Europeans generally cooperated in a comprehensive government program to halt soil erosion and to conserve water, the most critical of the country's natural resources. A part of this work is directed toward reversing trends set in motion by early European settlers.

Close to the height of land on the High Veld, where most of the country's streams begin, there were numerous bogs where grasses, herbs, and accumulated humus sponged up rainfalls and then fed the watercourses during at least a part of the dry season. African occupance had rarely disturbed this balance of nature, using the moist patches only for grazing cattle, if at all. European pioneers found bogs so numerous in places as to interfere with road-building, and their vicinity was malarial in spite of the high altitude. When settlers took up land, they began to drain the bogs to mitigate these discomforts, and to obtain the fertile soil for crops. Threefold damage to the land ensued: streams rose swiftly after rains and fell off sharply or ceased during the dry season; sheet-wash and erosion by the swollen waters became prevalent; the permanent ground-water level dropped alarmingly.

Roads have likewise altered the drainage pattern. They were laid out for convenience in moving about, and without consideration of potential gulleys. These may form during a few typically torrential showers, when the gathering waters turn a dusty route into a mud flow. Africans have accelerated roadway gulleying by making deep ruts with the runners of the heavy sleds on which they transport their goods (Fig. 60). Some of the early roads have become waterways and are now streams bearing names.

Under recent laws all surface water is vested in the state, and is apportioned and controlled by water courts. It is illegal to plow within 100 feet of a stream bank or a bog, unless the authorities grant specific permission to encroach. Farm dams to restore headwater bogs are recommended. Larger dams built by government agencies are thrown across streams farther down, to provide irrigation, in some cases coupled with storing city supplies. Contour plowing has come to be widely practiced.

With appreciation of the necessity for conservation, the European farm population has become increasingly critical of the Native Reserves, where much of the land continues to be overstocked and overcropped. The two contrasting groups are intermingled in such a way that they are likely to share physical units, such as stream basins and soils. Coarse sediment from Africans' land may be washed onto fertile soil of Europeans; gulleys started on a Reserve do not stop at its borders; grass fires on communal grazing lands may spread to European ranches. The reluctance of many African groups to accept measures that have only recently been adopted by the general run of European farmers is not surprising, but it calls attention to some fundamentals of inter-racial relations and tensions.

Crops and Livestock

In early days the one product of European farms that could be sure of finding a market was cattle, sold for meat in the towns and mining camps, with hides as an export. Later, mining districts as far away as the Union of South Africa and the Belgian Congo became markets. In 1950 there were 1,118,000 cattle on European farms and ranches—more than the maximum total ever owned by Africans and nearly twice the number that can be carried in good condition on the Native Re-

serves. The basic stock is Afrikander, but this hardy South African breed is constantly being up-graded with European sires. Over the decades serious diseases have successively or repeatedly attacked the herds, and cattle are dominant now only in the livestock ranching country of the west (Fig. 16), where herds of 600 to 1,000 are very numerous, while a few reach 5,000 head. Each animal requires from 12 to 20 acres, and ranches commonly comprise from 10,000 to 25,000 acres.

In that part of the country the critical problem of water is partially solved by evenly distributed wells pumped by windmills or sometimes by internal combustion engines, and by ponds made by throwing earthen dams across small streams. A

FIG. 63. Dairy cattle of North European stock, in planted pasture on the High Veld. *Courtesy of the Southern Rhodesian Government.*

few masonry dams of modest size impound water for irrigating forage crops, fed toward the end of the dry season and in case the rains fail.

Cultivated forage crops dependent on rains are being increasingly planted, but the natural grass remains the chief feed of ranch cattle. Small trees constantly encroach on savannas, and experts have reluctantly admitted that controlled burning at three-year intervals is the only practicable way of keeping down unwanted bush. It is agreed that short grass should not be burned, nor the taller grass if the cattle have eaten it well down. When it stands tall, the approved policy is to leave it until the first rain has brought up fresh green blades. Then, during the dry weather that usually follows, the pasture can be quickly burned over, after which fresh growth will immediately sprout again.

Cattle are herded by Africans on foot, who may or may not bring them into a

kraal every night. They are sure to drive them to the ranch-house once a week for dipping to kill ticks, as required by law. Dipping day is pivotal in ranch management, since all the animals can then be inspected.

Some cattle are kept on nearly every farm in the moister eastern part of the country, serving for draft, milk, and meat, in a system of mixed crop and stock farming. Dairy herds are increasing, to supply nearby towns with fresh milk and to provide cream for buttermaking (Fig. 63).

Land intended for crops is prepared by European plows, drawn by eight pairs of oxen, with a man to hold the plow and a boy to lead the animals (Fig. 64).

FIG. 64. Plowing last year's maize field with a European plow and Afrikander cattle. A man holds the plow, while a boy leads the team. High Veld, near Gatooma.

Wherever crops are dominant, maize occupies the largest acreage and until 1925 it was the only important cash crop. It is the staple food grain of the African population as well as the chief grain feed for animals, and a source of meal and oil for the Europeans. Any surplus finds a market in mining communities of neighboring countries, chiefly Transvaal. Because Africans prefer white corn, it has become standardized to facilitate export. Hybrid corn was introduced in 1934 from South Africa, which in turn had procured its seed from the United States. In that progression adaptations of the American crop to local conditions were made. Hybrid corn withstands drouth better than the open-pollinated variety, but both continue to be grown.

Maize is raised throughout the country, but about three-fourths of the crop

comes from the northeastern High Veld where the rainfall averages 30 inches or more (Fig. 65). In drier areas the yield is lower and less certain. Maize thrives best on the heavier soil, which is fertile and retentive of moisture. This soil responds well to applications of farm manure, and once in three or four years a green crop is plowed under. Maize can also be grown on the sandy lands, but subject to drouth.

Much of the maize is grown for sale, but it is increasingly combined in mixed farming with cattle—generally steers being fattened, but sometimes dairy cows.

FIG. 65. Farming country on the highest veld, not far from the eastern political border. Much of the least sloping land is under maize (in shocks). *Courtesy of the Southern Rhodesian Government.*

Such a farm needs 750 to 1,500 acres, somewhat less than half being in crops, with much of the rest in pasture. Crops in rotation with maize vary. Among them are legumes, either harvested or plowed under (peanuts, velvet beans, sunhemp), ensilage cut green for fodder, millet, buckwheat, potatoes, and cotton. One or two years of hay may be included in a rotation of three to five years. Pigs and poultry are minor items among the products of mixed farming.

At harvest the maize stalks are cut by hand and heaped in piles down the length of the fields. Because the dry season is dependable, the ears can be husked at leisure before being stored, commonly in granaries of native style and construction, but larger and more weatherproof. In most years stores are consumed in about four months. Once the grain is off the fields cattle are turned in to subsist on the

stalks, and the land between the heaps is plowed before it turns brick-hard as the dry season advances (Fig. 66).

A very little wheat is grown in the dry time of year, either in boglands or under irrigation, but only because it is in strong demand by the Europeans.

A specialized crop with a market in Europe is citrus fruit. The Chartered Company began experimenting in 1910, stimulated by the fact that wild lemons and oranges grew in a number of places. It has continued to operate three citrus estates, all in the northeast. All are irrigated, the largest from a reservoir created in 1920 by damming a water gap (poort) in a range of low mountains, at the base

FIG. 66. Cattle foraging on maize stalks after the ears have been husked. All land not covered by the beaten down shocks has been plowed during the early part of the dry season.

of which a piedmont stretches for 19 miles, providing heavy, alkaline soil and air-drainage as a guard against frost, for 70,000 orange and 1,000 lemon trees. The lemons and the largest oranges are marketed fresh in Southern Rhodesia. Culls go to a completely mechanized factory where they are converted into concentrated juice and oil from the rind, both products being marketed in Britain. Maize is grown by the Company on the level land at the base of the piedmont slope, primarily to feed the labor and the draft animals used in the citrus orchards. The two smaller citrus estates handle only fresh fruit.

Some fruits and vegetables (Fig. 67) are irrigated in the dry season in market gardens near the largest cities.

For a number of years the crop bringing the largest cash return has been to-

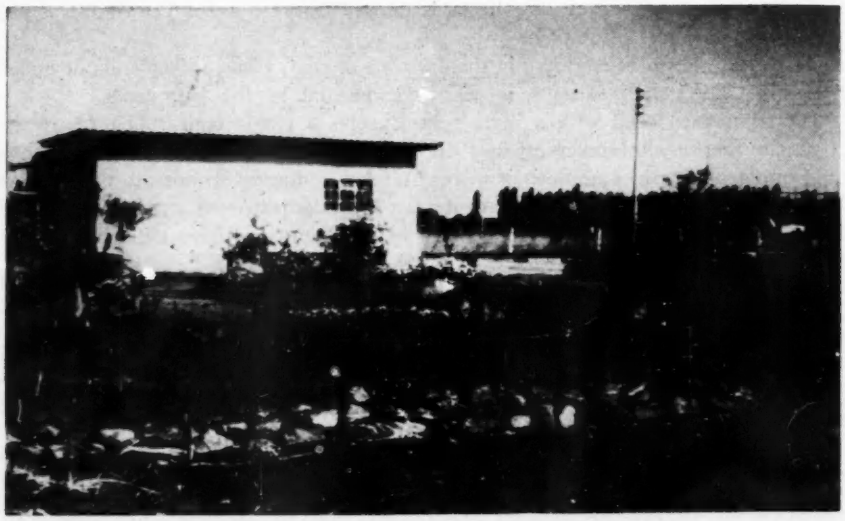


FIG. 67. A market garden outside Salisbury. Vegetables are irrigated by overhead spray (right, middle distance), so that they may be grown throughout the year.

FIG. 68. Tobacco seedlings under shade, being watered by hand. Natural bush, as seen in the distance, surrounds the seedplot.

bacco. It was grown by Africans before the present stage of occupance, and in spurts by Europeans since. About 1925 tobacco was given imperial preference, and Southern Rhodesia took the lead in producing for the British market. Its annual value amounts to more than half of the country's total crop and livestock production, and is the main reason why agricultural output exceeded minerals in value after 1950.

Tobacco is grown on sandy lands because the heavier, more fertile soil produces a coarse leaf. The light soil used tends to be orange-red, but may be buff or even gray. It must be enriched by chemical fertilizer; turning under green cover crops

FIG. 69. A tobacco field in fallow. The dark lines are dikes laid out along contours. The construction can be seen in the dike in the foreground (reinforced by a termite hill). In the distance is uncut bush.

is unsatisfactory. About half the total area of the country has suitable soil. Rainfall is more restricting, because the flue-cured Virginia type, which makes up more than 90 percent of the total, and the dark fire-cured (less than 1 percent) do best where the precipitation averages between 30 and 45 inches. Hence, practically all is grown in the northeast. The third type grown, Turkish, requires less rain and is cured in the sun of the dry season; it is planted over a wider area. Output of all types varies from season to season with amount and distribution of rain, and in any one year from farm to farm, depending on the timing and volume of showers. On adjoining farms a season's rain may vary five inches—enough to make the difference between bumper and unprofitable harvests.

The crop is started in seedbeds tucked away in virgin bush, to guard against plant diseases. Plantings (Fig. 68) at weekly intervals from September until January require irrigation and shade, until they are transplanted by hand to the fields. These slope gently (2° or 3°) to insure drainage, but are diked along the contours to conserve rainwater and prevent sheet wash (Fig. 69). Between the dikes low ridges are raised with a special plow, to keep water from standing on the roots. Harvest begins before the rains cease and lasts into the dry season. The leaves are hung in tall batteries of curing barns (Fig. 70), which are generally made of burnt brick but sometimes of adobe.

FIG. 70. A tobacco curing barn of burnt brick. Firewood from newly cleared bushland produces the heat that circulates among the rows of drying leaves. *Courtesy of the Southern Rhodesian Government.*

A field is planted to tobacco two years, and stands fallow for five. Oxen are used for plowing, which continues throughout the year. The average farm contains about 2,500 acres, one-fourth of which is suitable for tobacco, but only some 70 acres are planted to flue-cured leaf, or 35 acres to fire-cured, or 15 to Turkish. A larger acreage is in maize, grown to feed the laborers, the draft oxen, and sometimes steers being fattened for market. The rest of the holding is bushland, required for fuel for the curing barns. As the bush is consumed, the land is stumped for new tobacco fields. In recent years tobacco has been the only crop that repays

the clearing of bushland. Where the wood has been used up, some farmers are substituting Wankie coal.

A few farms are much larger than the average, running up to 1,200 acres in tobacco. Not more than 200 acres can effectively be managed as a unit; where a single owner plants more, he subdivides his cropland into units, each under its own supervisor. The factor that threatens to limit expansion of tobacco growing is shortage of African labor, because one man is needed for each acre in tobacco.

Tobacco is sold in large auction rooms, built for the purpose near the railway in Salisbury. The method of selling is borrowed intact from the United States

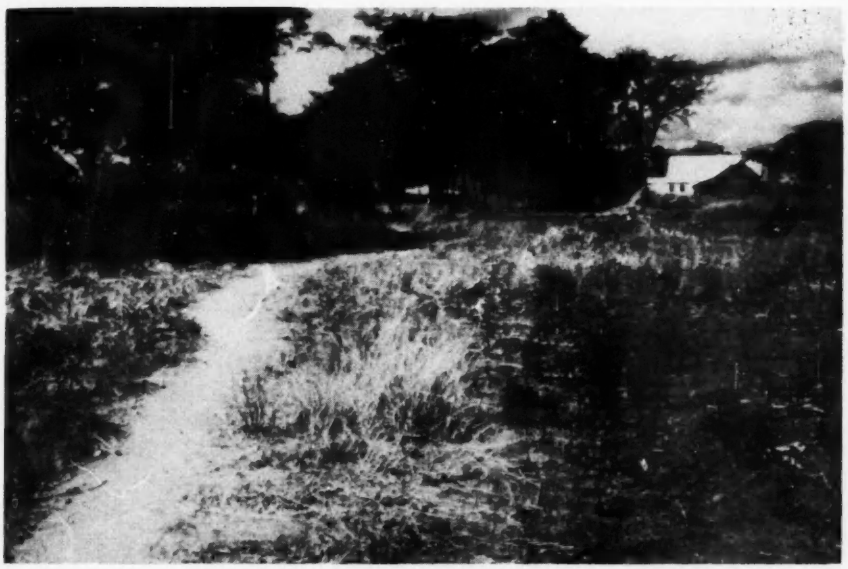


FIG. 71. A European farmstead. The path is of earth, beaten by bare feet.

South; even the auctioneers are North Carolinians. The leaf comes baled, and the auction "floors" are said to be the neatest in the world.

Rural Layout

In 1954 there were about 5,500 European farm holdings. Everywhere the essentials of a farmstead include the owner's house (Fig. 71), a well, a farmyard for livestock, and quarters for the African labor, preferably near a stream for water supply. Special equipment, such as tobacco barns, dipping tanks, and granaries are convenient to the farmhouse and yard. Contrasts are most marked between prosperous establishments of long standing, owned by British from the home islands or the Union of South Africa, and the bare necessities on land recently taken up by pioneering immigrants. Different in appearance from both are farmsteads belonging to Afrikaners from the Union.

The successful farm of British antecedents is a tropical version of an English estate. The house can rarely be seen from the road, because it is hidden in a planting of shade trees (Fig. 72) at the end of a long lane, bordered by eucalyptus in the drier parts and by evergreens where rain suffices. Its presence may be divulged by nothing more than a sign on the nearest public road (Fig. 73). The house is a rambling bungalow of burnt brick, with an asbestos or a shingle roof; broad verandas are a feature. The furniture is hand-made from local cabinet woods. Outside are flower and vegetable gardens, and there may be grounds for tennis and perhaps other sports. The farmyard and the kraal of the African laborers lie some distance off.

FIG. 72. The tree-lined avenue at the left leads from the public highway to a European farmstead. The gate at the right gives direct access to fields and pastures.

The Afrikaner may be equally prosperous, but his house is not large, and it is likely to be built of adobe and to have a roof of corrugated iron, or sometimes of thatch. It is entered under a small stoop, and furnishings go little beyond necessities. It may stand in full view of the road, and shade trees and flowers are few, although there is a large vegetable garden. The laborers' quarters may be a short distance down the road or across from the owner's house.

Africans perform all the labor on the European farms and ranches, making up the largest force of wage earners in any economic pursuit—213,000 in 1951, or 40 percent of the total employed. A few make their homes permanently on the farms, but most of them work for a period varying from some months to several years, after which they return to their tribal villages. Some men come from Native Re-

serves near enough to visit every week or so. If married, they leave their wives and children to raise food on the family's plot in the Reserve. Others, from farther away, generally remain on the farm for at least one crop year. Bachelors, and married men who leave their families back home, live several in a hut, and either cook for themselves or eat with neighbor families. As land becomes scarcer in the Reserves, more men are bringing their families with them. The farmer gives them permission to plant a patch of land with maize or other foodstuffs for their own subsistence. Legally they are squatters, but they are entitled to make year-to-year agreements that protect them against arbitrary eviction. Many wives and daughters of farm laborers obtain work in the fields, especially at peak seasons, and they account for nearly all of the 42,000 African women who earn wages.

FIG. 73. Signs pointing to farms and mines located on roads off the main highway.

The entire farmstead may be built by Africans drawn from the farm labor—men who know how huts and granaries are constructed in their home villages, and have learned brick-making, carpentry, and other building trades from Europeans.

The number of European farms is increasing. Subdivision below 250 acres is prohibited, but farms of this and even larger size often prove lacking in the balance of soil and water needed to support a family. Paradoxically, a large, well-located aggregate acreage in private hands is still unused, and farther from the centers lies much land that has never been taken up. The government has arranged easy terms for veterans of the world wars who purchase farm land. In spite of aid, new farm families are fewer than newcomers to the towns.

SOUTHERN RHODESIA AND ITS NEIGHBORS

The inland territory that came to be called Rhodesia in 1895 already had associations with the rest of Southern Africa. After 1885, when the Congress of Berlin threw open the interior of the continent to occupation by European nations, it lay in the path of conflicting national aspirations. Portugal hoped to join its east and west African coasts, while Cecil Rhodes undertook to implement his vision of a Cape-to-Cairo railway through territory to be made British.

Portuguese aspirations were quenched by the trek of the Pioneer Column in 1890. Within a year Britain and Portugal signed a treaty that reduced contacts to rail connections between the Mozambique coast and South Central Africa. Six years later the boundary was fixed by a neutral adjudication.

Countries to the South

Contacts with the British and Boer territories to the south have been close and continuous (Fig. 1). At the outset, Rhodes' British South Africa Company was made the instrument of his purpose to extend British authority northward. Its charter authorized it to obtain concessions from African chiefs, and to govern the resultant holdings and their inhabitants. It outfitted the armed Pioneer Column, most of whose 200 members came from South African colonies and states. It granted mining claims to them and to subsequent gold-seekers. Its representatives frustrated an early attempt of more than a hundred Transvaal Afrikaners to cross the Limpopo and occupy Rhodesian territory; two or three years later it welcomed the first prospective farmers, also from Boer states, but with British antecedents. It conducted military campaigns to subdue African tribesmen who rebelled against its administration. It built and operated telegraph and rail lines that linked the frontier to Cape Colony. These and subsequent ventures of the Chartered Company were financed in considerable part from the profits of South African mines.

The settlers in Rhodesia had a strong tradition of self-government, and in 1898 the Company was required by the British government to set up a small Legislative Council with representation of settlers as well as of the Company. It served as a law-making body, and the British High Commissioner in South Africa was given power to veto its acts. At the same time the legal system of Cape Colony was adopted. It was basically Roman-Dutch, but much English law has since been engrafted upon it. A Rhodesian High Court was set up, but appeals from its findings could be taken to the Supreme Court of Cape Colony. When the Union of South Africa was created in 1910, its Supreme Court at Bloemfontein took over appeals, and Southern Rhodesia entered into a customs agreement with the new dominion. Provision was also made for it to join the Union, if desired.

A change in government was impending, because the Company's charter was to expire in late 1914. By that date the Empire was at war, and the life of the charter was extended for a decade, during which the Union government offered favorable terms of amalgamation, while a party was organized in Southern Rhodesia to cham-

pion the contrary interests of those who wanted autonomy, preferably dominion status, within the Empire. Some 95 percent of the European population in 1920 had British backgrounds, and many disapproved of the Afrikaners who made up the remainder. A large number feared to join a far more populous country in which withdrawal from the British Empire was openly supported, and the Afrikans language was officially on an equal footing with English.

When the vote on future status was taken, three to two favored separate parliamentary government. This was set up in 1923. The European population, about 34,000, was adjudged too small to sustain a dominion, and the country remained a colony. The Chartered Company relinquished its administrative authority on payment from the Imperial Treasury for public works, including roads. It retained certain properties: all mineral rights, until 1933, when the Rhodesian government bought them; the railways, until they were similarly purchased in 1949; and investment in citrus orchards, forest plantations, mines, and flour mills, much of which it still holds.

A dozen years later Imperial supervision through the High Commissioner for South Africa was ended, and the few remaining powers, chiefly concerned with the status of the African indigenes, were vested in the Secretary of State for the Colonies in London.

There is a single voters' roll, which requires a property qualification. Both men and women can vote. At the beginning of 1953 the franchise was held by the following proportions of the various population groups:

	Franchise held by—	*Approximate total population*
Europeans	49,910	136,017
Asians	535	4,343
Colored	535	5,964
Africans	429	2,010,000 (est.)

All of the African population except this handful is ruled directly, through a Native Affairs Department of the government. More than 300 headmen are paid small salaries for maintaining law and order within their Reserves. Forty Native Councils advise the white officials. African courts hear suits between Africans according to traditional law and custom, but criminal offenses and cases affecting marriage are tried in European courts.

Ordinary legal duties concerning Europeans in outlying places are handled by the British South Africa Police, a mounted body with military training as cavalry. This is in the earliest tradition set by the Pioneer Column, which was under military discipline and was accompanied by a body of police. The state of the roads in most parts of the country still gives troopers mounted on horses more mobility than motorized units would have.

Countries to the North

When the Company handed the administration of Southern Rhodesia over to the settlers, it surrendered its political authority in Northern Rhodesia to the British

Crown. At that time, the southern unit opposed any degree of union with the northwest and the northeast, from which it had long before been separated for purposes of Company administration.

Not long after Southern Rhodesia became self-governing, federation of all the British colonies and protectorates north of the Limpopo was suggested. They are contiguous, but those to the north reach the sea by routes wholly separate from the railway to Beira on which the three political units to the south depend. The demand for closer ties soon split into proposals for two federations—an East Africa and a Central Africa. Northwestern Rhodesia (Fig. 1) was becoming a large-scale producer of minerals, which were exported via Southern Rhodesia from Beira. Power for the mines was furnished by Wankie coal. Northeastern Rhodesia merges without physical break into densely peopled Nyasaland, source of labor for the farms, the towns, and especially the mines of the other two areas. More recently Southern Rhodesia has begun to manufacture a wide range of goods wanted in the regions to the north. The reciprocal resources gave rise to working agreements, and a plan for political federation grew out of practical association.

Soon after World War II, the British government proposed a Central African Council to coordinate common interests of the three colonies. It was advisory, but it took the lead in setting up common services. Unified administration of the railway by representatives of both Rhodesias followed its purchase from the Chartered Company.

In 1953 the question of federation came to a vote in Southern Rhodesia. Nearly 40,000 ballots were cast, more than three-fifths of them favoring federation. Only those on the official roll had a voice in this constitutional change—proof that the African majority is in tutelage to the European minority.

Pursuant to the vote, a responsible federal government has been set up in Salisbury, with parliament and cabinet. Besides taking the stroke oar in the new federation, Southern Rhodesia retains its own parliament for handling local matters.

The European population of Southern Rhodesia has always grown by immigration more than by natural increase. Census figures indicate the size and rate of population growth since the beginning:

1891	1,500
1904	12,596
1911	23,606
1921	33,620
1931	49,904
1941	68,954
1951	136,017

Nearly all the immigrants have come from other British territory, the Union of South Africa and the British Isles accounting for most of them.

After World War II Southern Rhodesia was flooded with immigrants. The wave reached its peak in 1951 and then rapidly subsided. Most of these newcomers whose antecedents were in the British Isles went to the towns. The colony was unready to accommodate large numbers, and many, finding prices high and housing

difficult to obtain, soon departed for the Union of South Africa or elsewhere. Unofficial reports indicate that in 1953 6,000 left while 7,500 entered, the latter figure being only three-fifths of the immigration of two years before.

A distinction not made in the enumeration, but critical for the future of the country, is the proportion of Afrikaners to newcomers of British origin. Afrikaners began to arrive early, and have continued to move in ever since. After World War II their number increased rapidly. Most of them have settled in rural areas, and of late they have been drawn to the flourishing tobacco farms. For decades they have been criticized by members of the dominant group as unprogressive farmers and representatives of a way of life inimical to that of the British settlers. About 13 percent of Europeans living in Southern Rhodesia adhere to the Dutch Reformed church, and may be presumed to have Afrikaner sympathies. That is a large increase over the 5 percent of the early 1920's. The total population of Afrikaner origin is estimated at 16,000. Most of them speak Afrikaans at home, they publish a newspaper in Afrikaans, and they have been publicly charged with approving the political trends of the Afrikaner party in the Union. They constitute the core, although not the entire membership, of the minority party in the new federation that stands for segregation of the races. Southern Rhodesia has been described as more English than England, and because the war changed England greatly, there is much to justify that aphorism. Fear of being engulfed in the much larger and increasingly Afrikaner population of the Union has thrust the country into federation with Central African colonies beyond the Zambezi, in the hope of creating a political unit based on a solid foundation of economics and resources.

Economic vs. Social Structures

The economic reciprocity of the federation is apparent to all. The fact that it embraces segments of the two major Eurafrican social structures found in Africa south of the Sahara is less clearly seen.

Until now, the Zambezi River has been the demarcation between contrasting European attitudes toward the question of the races. South of the river, Europeans are in a minority (in Southern Rhodesia, about 1 to 15 Africans). Nevertheless, European interests always take precedence. It is assumed that the common roll for voting will grow, but that only those Africans who live in the European manner will be registered. The best that most Africans can hope for is guidance to improve their situation by working into the economic structure being developed by and for permanent European settlers. North of the Zambezi the Europeans constitute a tiny *élite* that exploits natural resources to satisfy a world market. Nearly all will return to the middle latitudes upon retiring (at an early age). Under favorable suzerainty, such as that of Britain, the Africans are treated considerately. To do so is humane, and it pays.

It is a crucial fact that the Federation of Rhodesia and Nyasaland straddles this critical boundary of race relations. The distinction rests squarely on the natural environment, but the differences are not clearly depicted in tables and maps.

A large fraction of the entire federated area lies above 3,500 feet, with a median average of about 4,000. This altitude does modify the climate, but in different degrees. South of the Zambezi Trough and near the margin of the low latitudes a compact unit of high veld comprises two-thirds of Southern Rhodesia, and nearly three percent of it lies above 5,000 feet. The combination of latitude and altitude strongly modifies conditions associated with the "tropics," and makes the country attractive to Europeans looking for permanent homes. North of the river only exceptional patches, mostly mountains, reach 5,000 feet, and the general level at about 4,000 feet is near enough the Equator to share the discouraging traits of low-latitude lowlands—their diseases and discomforts, their narrow range of crops and livestock, and their deficiencies in nutrition. Europeans who intend to live permanently in the region are concentrated in spots of high plateau, or settle near the railways, which keep to high ground on watersheds wherever feasible.

The Federation has politically unified three physical units of about equal size but far apart in character of population and stage of development. Southern Rhodesia is the key unit because it alone has a prospect of maintaining a European population sufficient to warrant a claim to autonomous political status. The swift rise and wane of immigration during the post-war decade raises a question that can be answered only by the years to come. If opportunities on the Southern Rhodesian High Veld do not attract a continuous and considerable flow of new settlers, the object of Southern Rhodesian (European) leaders may not be achieved. This distant double goal was stated by the Prime Minister in 1941:

> . . . the ultimate aim is . . . that the European, by his energy, modern knowledge and science, may protect himself in the African environment and preserve all the characteristics of mind and body which he has acquired . . . and at the same time . . . his influence, knowledge and care . . . may raise the African to become mentally and physically (i.e., in vigour) like a European.[29]

This goal is permanent co-existence of the communities that find themselves dwelling side by side in a natural environment suited to both. It rejects the policy of racial segregation dominant among Europeans in the Union of South Africa. It leaves room for the northern members of the federation to follow the lead of Southern Rhodesia, at least in those spots of high plateau where all races may find suitable permanent homes. In short, it is a statement that expresses the outlook of a region transitional in location and immature in its pattern of occupance. It points to a solution of Africa's race problem that may prove workable in other parts of the continent, or may fail in Southern Rhodesia itself.

A TEST CASE

In the introductory pages this study was announced as presenting a sample compage at the level of the province—a test case to exemplify proposals made in Chapter Two of *American Geography, Inventory and Prospect.* If the precepts there stated are sound, their practice should discover the facts and disclose the relations that give the resultant compage its distinctive character.

[29] *Comparative Survey of Native Policy in Southern Rhodesia* (London, 1951), p. 79.

The reader may conclude that this exposition of Southern Rhodesian geography, made according to formula, is not discernably different from a comprehensive study in the regional geography of this area made without recourse to a particular guide. If such is the conclusion, it may be that the writer has failed to follow directions; or alternatively, that the formula does provide the frame needed to keep within bounds the investigation of "the entire content of the human occupance of area," and to present the topics in "a flexible arrangement . . . of the subject matter, . . . the order [being] determined by the findings. . . ."[39]

The writer zestfully anticipates exemplifications by others of the theory and practice of regional geography.

SOURCES AND CREDITS

The study rests on field investigations in 1946 and 1951, discussions with Southern Rhodesians, government documents and maps, and published descriptions and narratives. The sources of quotations and illustrations are cited in the text. The remainder of the presentation is a selection of geographic bits drawn from a large number of publications and conversations, set in a matrix of the writer's observations.

Photographs not otherwise credited were taken by the author.

The maps have been drawn by Robert L. Williams, using data mainly from maps issued by the Government of Southern Rhodesia.

[30] *American Geography, op. cit.*, pp. 35 and 64.

MANGROVE SWAMPS OF THE PACIFIC COAST OF COLOMBIA*

ROBERT C. WEST

Louisiana State University

THE peculiar plant forms and associations that characterize mangrove swamps along tropical coasts have long attracted the attention of botanists and plant ecologists. Today there exists a large literature on the physiology and ecology of mangrove for selected areas of the tropics. On the other hand few investigators have studied mangrove swamps from a geographical point of view, with emphasis on physical and cultural relationships. Even the world distribution of mangrove is imperfectly known, and students still disagree on fundamental physical processes involved in the formation and development of mangrove coasts.[1]

Mangrove swamps occur in the tidal zone of most low alluvial coasts in the humid tropics. The peculiar morphological adaptation of the plants to a saline environment, as well as the characteristic hydrography and landforms of the swamp, makes the mangrove forests one of the most distinctive of tropical areas. Such characteristics also present special problems for travel and subsistence in the swamps. Colombia's Pacific tidal forests, which contain the most luxuriant mangroves in the world, afford excellent opportunities for the study of swamp ecology and geography.

THE PACIFIC COAST OF COLOMBIA

The Pacific littoral of Colombia and adjacent areas is characterized by two distinct coastal types: (1) a high, mountainous coast that extends northward from Cabo Corrientes to the Gulf of San Miguel in southeastern Panama and (2) a low, alluvial coast fringed by dense mangrove forests and sandy beaches, which stretches southward from Cabo Corrientes for more than 400 miles into Esmeraldas province, northwestern Ecuador (Fig. 1). The latter coast represents the most extensive area of mangrove in northwestern South America. It occupies the tidal fringe of a narrow coastal plain, five to thirty miles wide, which is being formed by mate-

* Field work for this study was done under ONR contract during the summer months of 1951, 1952, and 1953.

[1] Most of the literature on mangrove is scattered through a large number of botanical and forestry journals. A lengthy bibliography on mangrove is given in Ferdinand Grewe, "Africanische Mangrovelandschaften. Verbreitung und wirtschaftsgeographische Bedeutung," *Wissenschaftsliche Veröffentlichungen des Deutschen Museums für Länderkunde zu Leipzig*, N.F. 9 (1941), pp. 103–177. Although based on library research and limited to Africa, this monograph is one of the few studies that treats the mangrove swamp as a geographical area. A valuable but outdated general survey of mangrove swamps written from a botanical point of view is H. H. M. Bowman, "The Ecology and Physiology of the Red Mangrove," *Proceedings of the American Philosophical Society*, Vol. LVI (1917), pp. 589–672. A more recent summary is found in P. W. Richards, *The Tropical Rain Forest. An Ecological Study* (Cambridge, 1952), pp. 299–312.

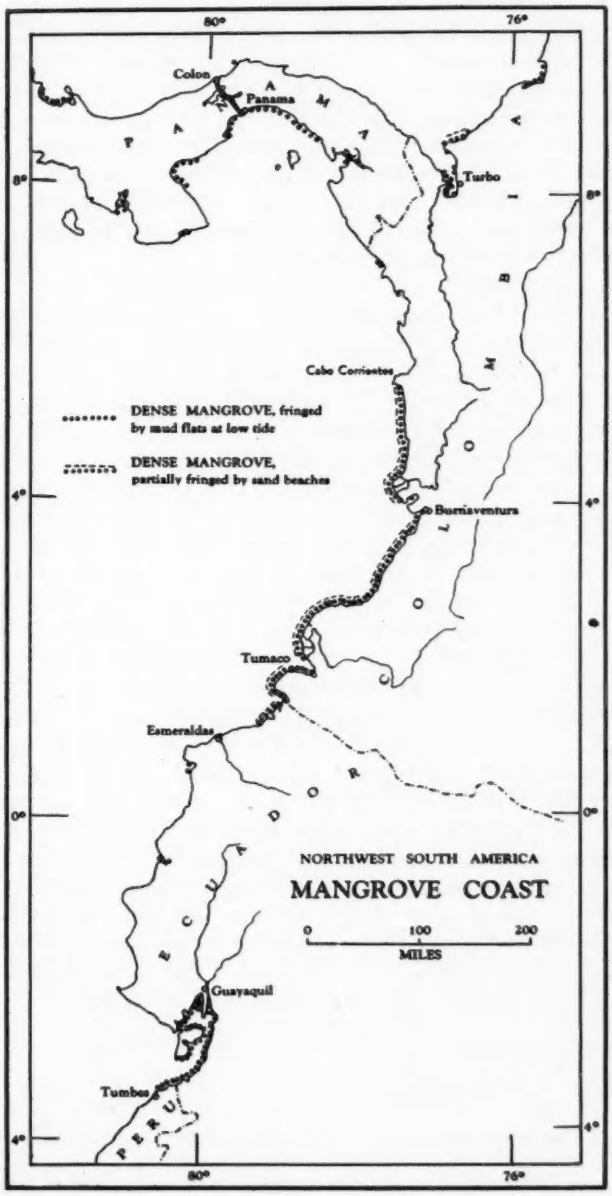


FIG. 1. The extent of mangrove swamps along the coast of northwestern South America. Tumbes, northern Peru, represents the southern limit of mangrove on the Pacific coast of the Americas.

rial deposited by streams flowing from the western versant of the Andes. These streams carry an enormous volume of water, and probably a large load, for they drain areas that receive an annual rainfall of 200 to 400 inches. The entire tidal fringe is a series of coalesced deltas formed by these streams. Cut by hundreds of estuaries and tidal channels, the low coast presents an extremely irregular outline. The coastal alluvium is not entirely continuous, for at three places it is interrupted by consolidated Tertiary material that reaches the sea to form steep cliffs partially covered by rain forest. One interruption occurs in a 25-mile strip just west of the Bay of Buenaventura; another is a short section immediately south of Buenaventura, called Las Tortugas; and a 15-mile stretch of rocky coast occurs on the Ensenada de Tumaco.

Excepting the three cliffed areas, the alluvial coast from Cabo Corrientes to slightly beyond the Santiago River estuary in Esmeraldas is distinguished by four geographic belts arranged in sequence from the sea inland: (1) a belt of shoal water and mud flats immediately off coast; (2) a series of discontinuous sand beaches, interrupted by tidal inlets, estuaries, and wide mud flats; (3) the zone of mangrove forest, usually one-half to three miles wide; (4) a belt of fresh-water tidal swamp, which lies immediately back of the brackish-water mangroves. Inland from the tidal swamps on slightly higher ground is the equatorial rain forest that covers the greater part of the Pacific lowlands of Colombia. This zonation appears to be typical of most mangrove coasts of the world, although the beach zone is frequently absent. It is described for the Malay Peninsula by Watson[2] and Dobby,[3] for the west coast of Africa by Grewe[4] and Pynaert,[5] and for the Guiana coasts of northern South America by Martyn.[6]

The Pacific coast of northwestern South America is affected by a large tidal range characteristic of most eastern shores of the Pacific Basin. A mean range of eight to ten feet and a spring range of eleven to thirteen feet occur along most of the low Colombian coast. During high tide brackish water penetrates one to four miles into the coastal fringe; the tide may reach many miles up the courses of the larger rivers. Along the immediate shore deposition and scour by tidal currents become important factors in shaping various coastal landforms, such as channels, flats, bars, and parts of beaches. Longshore currents also are effective depositional and erosional agents along the coast. The prevailing southwest winds motivate a northward-flowing longshore current, which transports and redeposits quantities of mud and sand immediately off coast. Aided by wave action, these currents form the sandy beaches that fringe approximately 45 percent of Colom-

[2] J. D. Watson, "Mangrove Forests of the Malay Peninsula," *Malayan Forest Records*, No. 6 (1928), pp. 1–275.

[3] E. H. G. Dobby, *Southeast Asia* (London, 1950), p. 67.

[4] *Op. cit.*, pp. 112–115.

[5] L. Pynaert, "La mangrove congolaise," *Bulletin Agricole de Congo Belge*, Vol. XXIII (1933), pp. 184–207.

[6] E. B. Martyn, "A Note on the Foreshore Vegetation in the Neighborhood of Georgetown, British Guiana," *Journal of Ecology*, Vol. XXII (1934), pp. 292–298.

bia's mangrove coast. The remainder of the tidal swamp grows to the edge of the sea in quiet bays and estuaries protected from strong waves and along shores fronted by extensive mud flats.

DEVELOPMENT OF MANGROVE SWAMP

Mangrove forests appear to develop best under the following physical conditions:

1. *Tropical temperatures.* Well-developed mangrove is found along coastal areas where the average temperature of the coldest month exceeds 20° C. (68° F.), and where the seasonal temperature range does not exceed 5° C. (9°F.).

2. *Fine-grained alluvium.* Mangrove best develops along deltaic coasts or near river mouths where abundant soft mud composed of fine silt and clay, rich in organic remains, is available for the growth of seedlings. (In the western Pacific Basin, mangrove occurs on coral reefs; but such growth is stunted and can be considered abnormal).

3. *Shores free from strong wave action.* Mangrove cannot tolerate strong wave action, neither for the growth of seedlings nor for the maintenance of mature forests. Thus mangrove best develops along the shores of protected bays and estuaries, or back of barrier beaches.

Mangrove is said also to develop best along tropical coasts having abundant rainfall evenly distributed throughout the year. Such a correspondence does occur usually, but the areas of heavy rainfall are also those having many sediment-laden streams, which make available large quantities of loose, wet alluvium at their mouths and along edges of bays. Moreover, salinity does not seem to be a physical requirement for the growth of mangrove. It has been shown that some members of the mangrove community (especially *Rhizophora*) will thrive as well in fresh-water conditions as in a saline habitat, or even better.[7] Thus it appears that mangrove, being physically adapted to saline conditions, occupies tidal areas where more aggressive fresh-water plants, intolerant of salt, cannot exist. Again, a large tidal range is often cited as a prerequisite for optimum growth of mangrove.[8] Although the tide *per se* probably has little importance in determining the existence of mangrove, given a shore of constant gradient, the greater the tidal range, the wider the belt of alluvium affected by saline water, and thus the wider the belt of mangrove.

Along the low Pacific coast of Colombia the three prime requisites for mangrove development listed above are present. As indicated previously, at high tide salt to brackish water penetrates inland along tidal channels for several miles, flooding twice each 24-hour period a wide area of coastal alluvium. Generally the mangrove belt is one to four miles wide, but in the Tapaje-Sanguianga delta north of Tumaco it reaches a maximum width of fifteen miles; just south of Cabo Corrientes, however, mangrove occupies a narrow fringe of mud not more than five to

[7] Frank E. Egler, "The Dispersal and Establishment of Red Mangrove, *Rhizophora*, in Florida," *The Caribbean Forester*, Vol. IX (1948), pp. 299–320, ref., 308.

[8] F. W. Foxworthy, "Distribution and Utilization of the Mangrove-swamp of Malaya," *Annales du Jardin Botanique de Buitenzorg*, Supplement 3, part 1 (1910), pp. 319–344.

ten feet wide at the base of jungle-covered sea cliffs. Narrow ribbons of mangrove penetrate inland many miles along the banks of streams as far as salt or brackish water occurs at high tide.

The mangrove forest of the Pacific coast of Colombia is distinguished by its tall trees. One component of the mangrove association—red mangrove (*Rhizophora*)—grows to heights of over 100 feet, some trees having a diameter of over

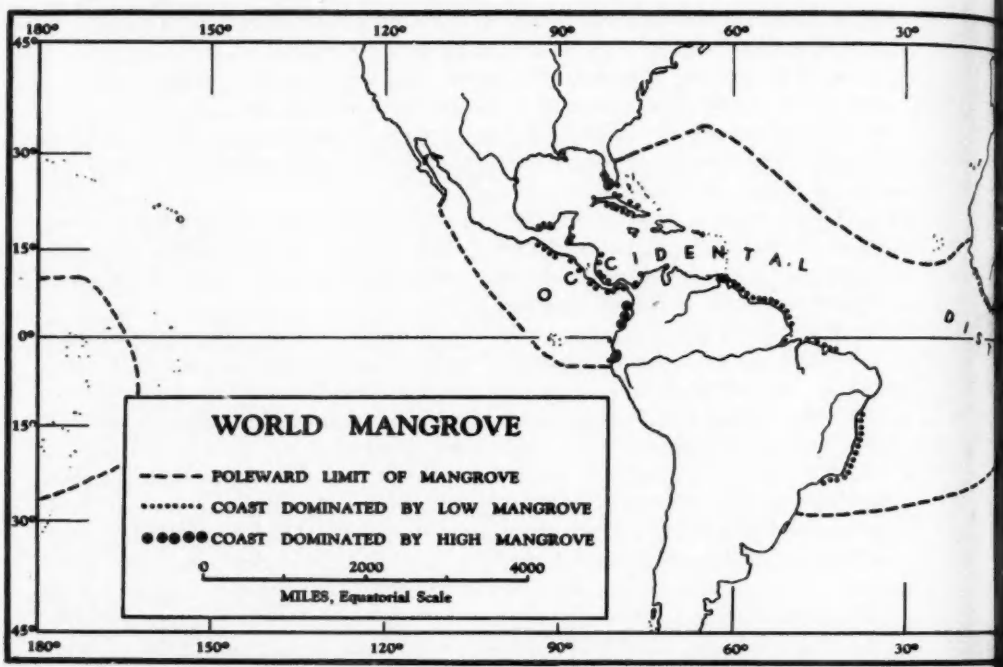


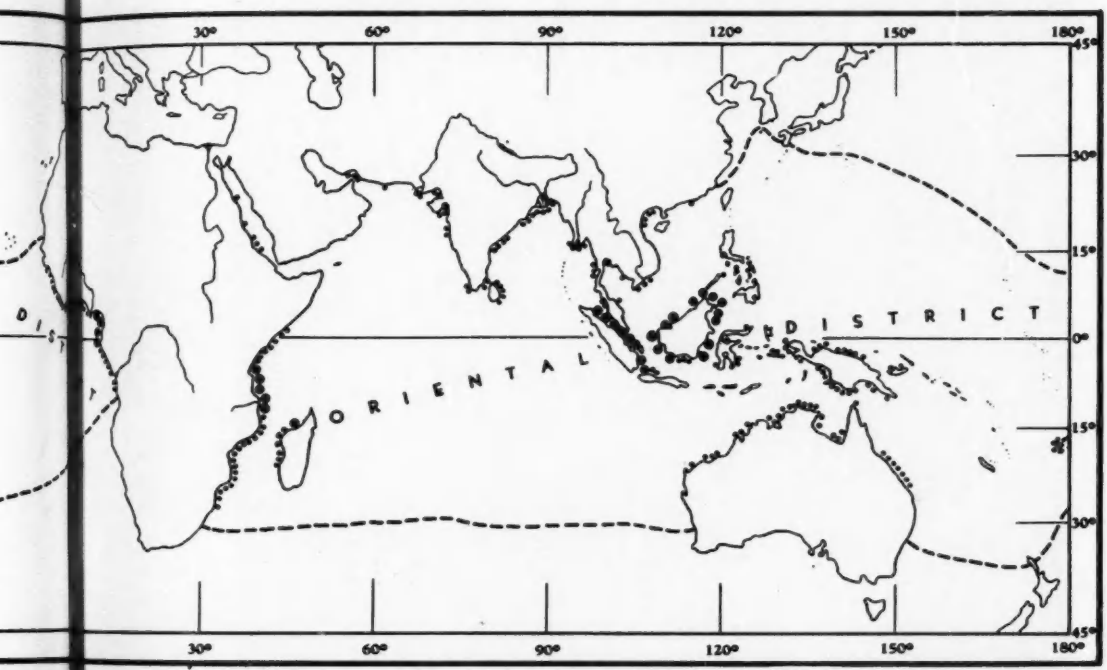
FIG. 2. World distribution of mangrove. Low stands of *Avicennia nitida* usually occur along the poleward li... the Red Sea coast of northeastern Africa.

three feet. Only two other mangrove forests in the American tropics are characterized by such luxuriance: (1) the eastern shore of Guayas Bay, southern Ecuador, near the poleward limit of mangrove on the Pacific coast of South America[9] and (2) a small section within the Ten Thousand Islands area of southwestern Florida, again near the poleward limits of mangrove in the northern hemisphere (Fig. 2).[10] Mangrove along other coasts of tropical America is characterized by relatively

[9] Baron H. von Eggers, "Die Manglares in Ecuador," *Botanisches Centralblatt*, Vol. LII (1892), pp. 49–52.

[10] J. H. Davis, "The Ecology and Geologic Role of Mangroves in Florida," *Papers from the Tortugas Laboratory of the Carnegie Institution of Washington*, Vol. XXXII (1940), pp. 303–412.

low, scrubby forests. Elsewhere tall mangrove forests comparable to those of the Colombian Pacific coast are found on the shores of the Cameroons and eastern Nigeria in Gulf of Guinea, West Africa;[11] along the coast of Tanganyika, East Africa;[12] and in various parts of southeast Asia, such as the north coast of Sumatra and much of the coast of Borneo,[13] where mangrove forests probably reach their maximum development.



mangrove. It is found frequently along the gulf coast of Texas and Louisiana, and it dominates the mangrove swamp of

COMPOSITION AND STRUCTURE OF THE MANGROVE FOREST

Botanically the mangroves of the Pacific coast of Colombia belong to the Occidental Mangrove District, which encompasses tropical America and the Atlantic coast of Africa (Fig. 2). Four major genera form the bulk of the mangrove trees

[11] D. R. Rosevear, "Mangrove Swamps," *Farm and Forest*, Vol. VIII (1947), pp. 23–30, reports red mangrove in Nigeria as high as 151 feet with girth of nearly eight feet.

[12] D. K. J. Grant, "Mangrove Woods of Tanganyika Territory, their silviculture and dependent industries," *Tanganyika Notes and Records*, No. 5 (1936), pp. 5–16.

[13] F. W. Foxworthy and D. M. Matthews, "Mangrove and Nipah Swamps of North Borneo," Department of Forestry, B. N. B., *Bulletin No. 3* (1917).

in this district: *Rhizophora* (red mangrove), *Avicennia* (black mangrove), *Laguncularia* (white mangrove), and *Conocarpus* (sometimes called "buttonwood").[14] On the Pacific coast of Colombia *Rhizophora brevistyla* and, occasionally, *Rh. samoensis* are the species of red mangrove that form the dominant component of

FIG. 3. Forest of red mangrove (*Rhizophora brevistyla*) along tidal channel north of Tumaco. Tall trees and well developed prop roots typify the tidal forest.

the tall swamp forest. *Avicennia nitida, Laguncularia racemosa,* and *Conocarpus erectus* are low trees, and in terms of area are less significant members of the

[14] In contrast, the Oriental District, which includes the tropical coasts bordering the Indian Ocean (East Africa, Madagascar, India, Malaya, and northwestern Australia) and the western Pacific Basin (southeast Asia, northern Australia, and the western Pasific Islands) contains fifteen genera and more than twenty species. *Rhizophora, Ceriops, Sonneratia, Bruguiera, Acanthus,* and *Avicennia* are among the more important genera represented. For a tabulation of species in the Oriental District see Grewe, *op. cit.,* p. 107.

swamp. A fifth mangrove tree, *Pelliciera rhizophora,* a member of the tea family, is found only on the Pacific coast of tropical America.[15]

Although unrelated botanically, the trees of the mangrove forest exhibit certain common morphological adaptations to their saline environment; these adaptations are reflected in the strange physiognomy of the plants. One of the most spectacular features is the aerial root system. The red mangrove has developed (1) large

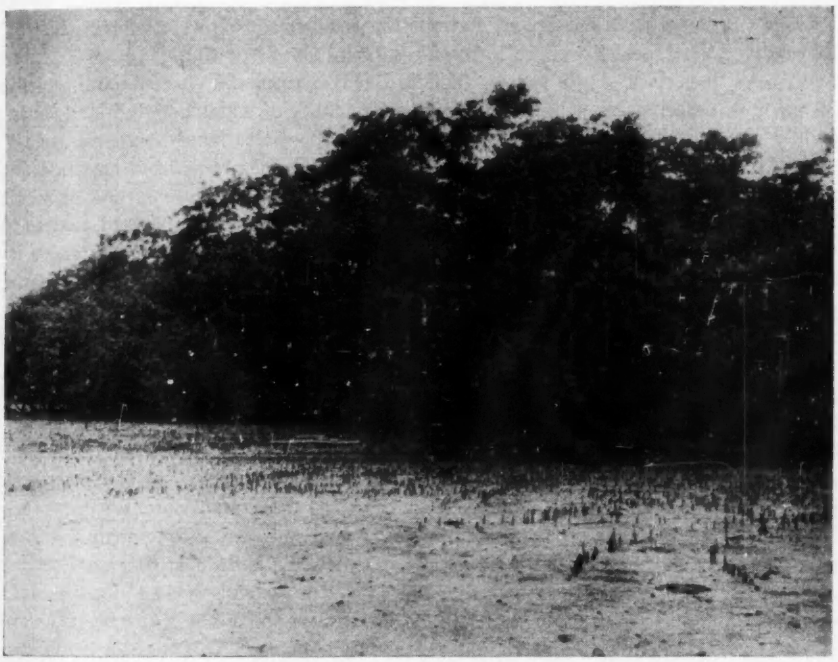


FIG. 4. Stand of young black mangrove (*Avicennia nitida*) on mud flat, at low tide, south of Buenaventura. Protruding above the mud in the foreground are the asparagus-like "pneumatophores," among which are a few *Rhizophora* seedlings.

prop (or stilt) roots which raise the trunk high above the ground and (2) long drop roots that grow from the branches into the mud below. When exposed at low tide these gnarled roots, often ten to fifteen feet high, form an almost impenetrable maze of vegetation (Fig. 3). Along tidal channels the prop and drop roots rise from a surface of soft, brackish ooze, into which a man would sink to his knees. Black mangrove (*Avicennia nitida*) is characterized by a system of surface roots which send up sharp-pointed asparagus-like shoots five to six inches above the

[15] José Cuatrecasas, "Mangroves of the Pacific Coast of South America" [Abstract], *A Series of Lectures presented before the Department of Botany Seminar, Northwestern University, by the Botanical Staff of the Chicago Natural History Museum* [1952], pp. 8–10.

ground. The rigidity and sharpness of these pneumatophores, together with the soft, slippery ooze in which they grow, make walking through black mangrove thickets at low tide a difficult procedure (Fig. 4). Another peculiar adaptation of mangrove plants is called vivipary, or the germination of seeds inside the fruit before separation from the mother plant. Mangroves, therefore, should reproduce and colonize new mud flats quickly, but due to destructive wave and current action, such is often not the case, as pointed out below.

Like most tropical swamp vegetation, the mangrove forests are characterized by relatively few species and the formation of solid stands of single species. Moreover, belts of certain single species tend to develop from the shore inland, chiefly on account of decreasing salinity and increasing acidity of water and soil landwards. Belted patterns of mangrove have been reported especially from southeast Asia,[16] East Africa,[17] Florida,[18] and the Caribbean.[19] Such zones have been assumed for most mangrove areas in the humid tropics. Along the Pacific coast of Colombia, however, definite belts of single species are difficult to observe in the field, and such arrangements may be obscured by many local factors, such as areal differences in salinity, varying degrees of exposure to wave and current action, and variations in grain size and organic content of alluvium. Nevertheless, stands of almost pure giant *Rhizophora* are usually best developed in a belt of varying width along the edge of tidal channels where there is an accumulation of soft clayey mud and complete flooding by the tide twice each 24-hour period. Inland, belts of *Avicennia* and dwarf *Rhizophora* sometimes occur. Proceeding up an estuary, one often encounters stands of *Rhizophora* in the lower section, followed by stretches of *Avicennia* and *Laguncularia,* and finally growths of *Conocarpus erecta* in the drier and less saline areas. These formations gradually merge with fresh-water swamp vegetation farther upstream. On the other hand, the following arrangement is often observed from the edge of the tidal channels inland: *Laguncularia racemosa,* forming a low growth on the channel edge is followed by a narrow belt of *Avicennia* farther inland; finally in the interior an extensive forest of giant *Rhizophora brevistyla* is found. Along the coast immediately back of sand beaches the belted arrangement is even more confused, and in many cases nonexistent. Often solid stands of *Avicennia nitida,* fifteen to thirty feet high, occur immediately behind the beach along the edges of lagoons; this belt is followed by *Rhizophora* forest (Fig. 5). In other cases *Rhizophora* fronts on the lagoons and even the open coast, if protected from wave action by mud flats and bars offshore. The belted arrangement of mangrove by species is further confused by the odd-looking *Pelliciera*

[16] Watson, *op. cit.,* p. 2.

[17] B. M. Graham, "Notes on the Mangrove Swamp of Kenya," *Journal of East Africa and Uganda Natural History Society,* No. 29 (1929), pp. 157–164.

[18] Frank E. Egler, "Southeast Saline Everglades Vegetation, Florida, and Its Management," *Vegetatio,* Vol. III (1950), pp. 213–265.

[19] V. J. Chapman, "The Botany of the Jamaica Shoreline," *Geographical Journal,* Vol. XCVI (1940), pp. 312–323; R. A. Howard, "Vegetation of the Bimini Island Group, Bahamas," *Ecological Monographs,* Vol. XX (1950), pp. 317–349.

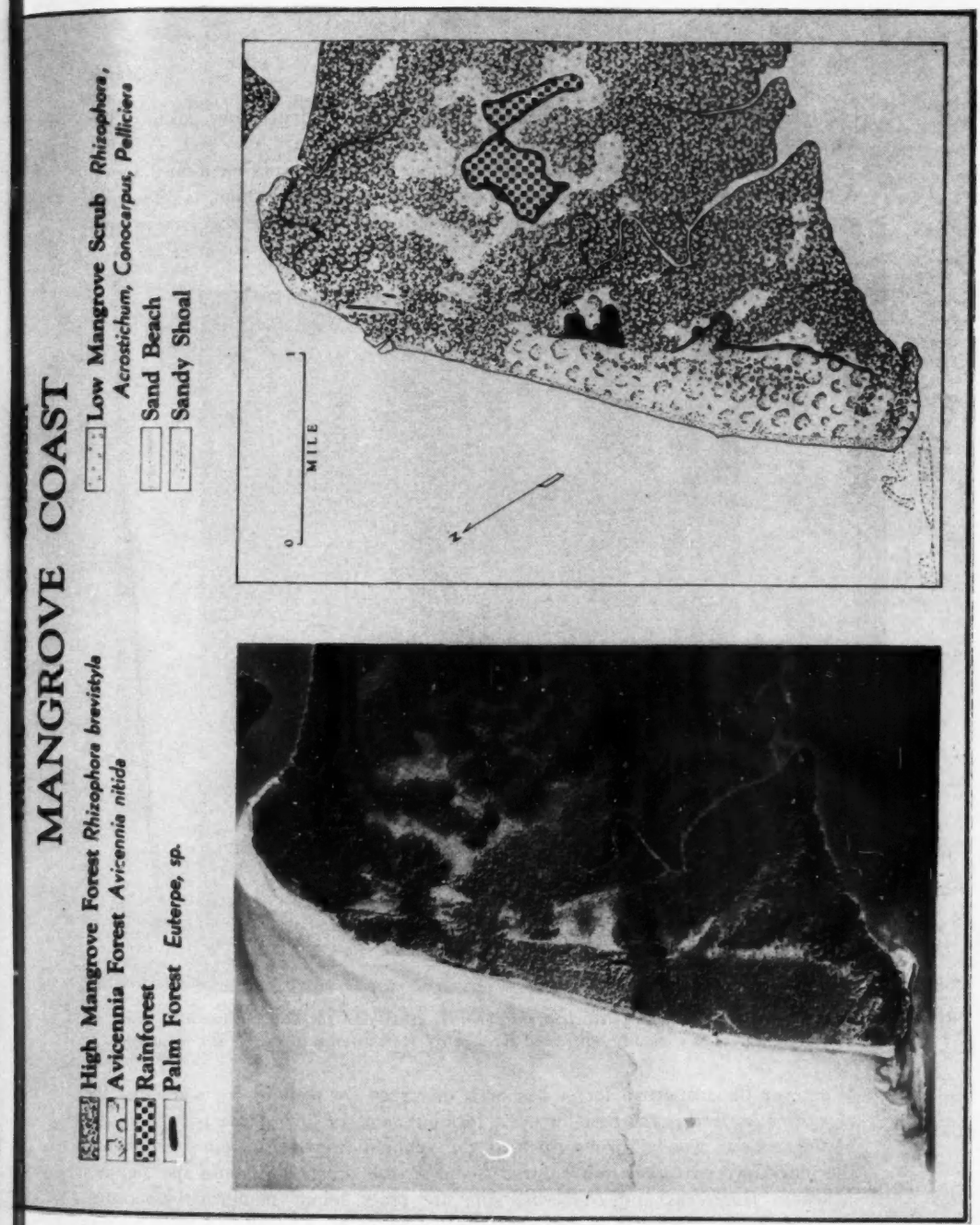


FIG. 5. A typical portion of the mangrove coast of Colombia, south of Buenaventura. The tones in the photograph ate the vegetational patterns of the swamp forest. The dark tones indicate mature red mangrove; medium tones of the beach correspond to black mangrove (*Avicennia*); patches of low mangrove scrub in the interior are shown e light tones. Feathery texture in the lighter tones mark areas of palm growth.

(U. S. Army Air Forces photo. 2–2016; 2–211V; 142, 143; 1943)

rhizophora, which occurs in small communities in exposed positions, such as the seaward tips of point bars in estuaries or in spots having hard, clay soils (Fig 6).

Many low plants are associated with the main mangrove types mentioned above. A brackish-water fern (*Acrostichum aureum*), five to eight feet high, is often seen growing along the tidal channels in the midst of high *Rhizophora;* this fern is especially common in the inner mangrove zone near the freshwater swamp (Fig. 7).

FIG. 6. The *iguanero* (*Pelliciera rhizophora*), estuary of the Río Yurumanguí, south of Buenaventura. The curiously buttressed trees range from twenty to thirty feet in height.

Wherever the mangrove forest has been disturbed by man or by windfalls, the *Acrostichum* fern is the first intruder, forming spots of low, dense growth in the swamp. Low, woody shrubs, such as the yellow-flowered *Pavonia rhizophorae,* the blue-flowered *Conostegia polyandra* and *Rustia occidentalis,* and the legumes *Muellera frutescens* and *Dalbergia* spp. are other minor mangrove associates. Growing on the trunks and prop roots of *Rhizophora* are epiphytes, mainly orchids

and bromeliads (*Tillandsia* spp.), which give a further eerie aspect to the swamp. Many of the bromeliads contain reservoirs of fresh rain water, which make ideal breeding places for various species of the *Anopheles* mosquito within the mangrove swamp.[20]

FIG. 7. Interior of red mangrove forest on peaty surface, near estuary of Río Potedó, south of Buenaventura. The tall fern is *ranconcha* (*Acrostichum aureum*). Orchids and bromelias grow as epiphytes on trunks and prop roots.

Associated with the belted arrangement of vegetation in the swamps is the existence of curious rounded patches of low scrubby growth in the interior of the high mangrove (Figs. 5, 11). The vegetation in these patches is only four to six feet

[20] Lyman B. Smith, "Bromeliad Malaria," *Annual Report of the Smithsonian Institution, 1952* (Washington, 1953), pp. 385–398.

high, composed of dwarfed *Rhizophora* with stunted prop roots, mixed with *Avicennia nitida, Acrostichum* fern, and other brackish-water plants (Fig. 8). These areas occupy ground that is slightly higher and drier than the channel banks. They are flooded usually by semi-monthly tides only. The soil is peat-like, soggy, quaking underfoot; a heavy man sinks to his ankles in the top muck. Often in the cen-

FIG. 8. Patch of low vegetation, including dwarf *Rhizophora*, interior of mangrove forest, south of Buenaventura. The plants in the foreground are from six to eight feet tall.

ter of these patches one finds hammocks of the *naidí* palm (*Euterpe Cuatrecasana*), a plant characteristic of the fresh-water swamp, or in some instances, even clumps of equatorial rain forest. The centers of the patches are the highest, driest, and firmest parts of the mangrove swamp, but they are extremely difficult to reach. The occurrence of these rounded areas of low growth is typical of other mangrove forests; for example, along the coast of Burma such patches are called "byiaks"

and are readily noticed on aerial photographs.[21] The formation of these features is probably due to the slow rise of land through decay of mangrove vegetation. The underlying peat contains remains of large *Rhizophora* roots and trunks. Such features may be identical with the so-called "ombrogenous moors" found behind mangrove swamps in Sumatra. These moors are characterized by stunted growth developed on highly acid soil underlain by lens-like deposits of peat.[22] Owing, perhaps, to acidity and lack of fine muddy sediment rich in organic matter, tall mangrove forests fail to regenerate themselves in the inner channel areas.

FIG. 9. A tidal channel, or *estero,* at high tide within the mangrove forest, north of Tumaco. *Rhizophora brevistyla* is the dominant tree.

HYDROGRAPHY, LANDFORMS, AND SOILS

The interior of the mangrove swamp is occupied by a complex system of short, meandering tidal channels, known as *esteros.* Wide in their lower courses, the esteros suddenly narrow to small creeks a short distance upstream. During high

[21] L. D. Stamp, "The Aerial Survey of the Irrawaddy Delta Forests," *Journal of Ecology,* Vol. XIII (1925), pp. 262–276. Similar features are noted for the mangroves of West Africa by Pynaert, *op. cit.,* p. 189, and by Rosevear, *op cit.,* pp. 23–30. They have also been observed in the mangrove on the north coast of Sumatra by A. Kint, "De Luchtfoto en de topografische terreingesteldheid in de Mangrove," *De Tropische Natuur,* Vol. XXIII (1934), pp. 173–189.

[22] These moors are described by Richards, *op. cit.,* pp. 214–216.

tide the channels are brim-full, and brackish water overflows into the surrounding swamp forest. At low tide the smaller esteros become dry, while the deeper ones are transformed into shallow creeks, with exposed parts of fallen logs projecting above the water at all angles, making navigation extremely hazardous (Fig. 9). Immediately back of the present beaches and seaward sections of mangrove swamp, lagoons and tidal channels are arranged parallel to the coast, and thus connect the lower parts of river estuaries. Such channels form an almost continuous inland

FIG. 10. Freshly deposited mud along edge of tidal channel at low tide in mangrove forest near Buenaventura. The maze of *Rhizophora* prop and drop roots in this case appear to have aided deposition.

waterway along the entire length of the mangrove coast. They also separate sizeable areas of swamp (called *islas*) from the mainland. Canoes and small launches use the quiet water of the esteros for coastwise travel, rather than risk the turbulent swells and waves at sea, or "por afuera." Travel "por adentro" along the inland channels, however, must be closely timed to correspond with periods of high tide. More than once the writer has been stranded for several hours in a canoe stuck on the muddy bottom of an estero at low tide, being pestered to distraction by black flies and mosquitoes until the water slowly rose with the incoming tide.

Fine, soft mud, deposited and reworked by tidal currents, accumulates on the

edges of the channels between the prop roots of *Rhizophora* and the asparagus-like pneumatophores of *Avicennia*. Low tide exposes the muddy banks of the channels as well as mud flats, three to ten feet wide, on the slip-off slopes of meander bends (Fig. 10). The soft mangrove mud is blue-black in color, composed of sediments with grain size of less than 0.02 mm., and rich in remains of partially decayed organic matter. The decomposition of organisms in the oxygen-poor mud, combined with the activity of anaerobic bacteria, gives rise to the quantities of hydrogen sulphide that cause the characteristic stink of mangrove swamp.[23] Along the banks of tidal channels, where sediment is newly deposited, the mud is extremely soft, into which a heavy man readily sinks to his knees; alighting on the bank from a canoe at low tide is thus a formidable task, and can be done best by supporting one's self on the slippery prop roots of *Rhizophora*. Inland from the channel banks the mangrove soil becomes firmer; by reason of countless capillary rootlets growing from the props of *Rhizophora* just below the surface, the soil gradually becomes hardened, taking on a peaty texture. On such a surface one can walk rather easily at low tide, sinking up to the ankles in peaty muck. As one goes farther inland the soil becomes firmer, until the patches of low growth described above are reached; there, one must cut his way through the thickets with a machete.[24]

Although fauna in the mangrove swamp is relatively poor in species, at least two kinds of animals are significant in the development of soil and vegetation. Various crabs,[25] by digging holes in the mud, help aerate the soil; these animals thus perform the same function as earthworms in fresh-water soils. Their holes also cause small depressions in the mud surface, which serve as loci for further sedimentation by tidal waters. On the other hand, crabs destroy seedlings and thus help prevent the formation of undergrowth in the mangrove forest. Many mollusks, including oysters and clams, attach themselves to the prop roots of *Rhizophora*, and their shells become important sources of calcium carbonate needed by red mangrove in large amounts for proper growth.[26]

[23] The chemistry of mangrove soils has been studied by F. W. Freise, "Untersuchungen am Schlick der Mangrovküste Brasiliens," *Chemie der Erde*, Vol. II (1938), pp. 333–355. The blue-black color of mangrove mud is probably the result of the reaction between hydrogen sulphide and iron, which produces the blackish iron sulphide. Along banks of tidal channels the blue-black mud is often covered by a thin (1–5 cm.) layer of grey-brown mud, recently deposited by tidal currents and possibly affected chemically by oxygen contained in the brackish water.

[24] Similar soil types and vegetation sequences are described by Rosevear, *op cit.*, p. 24, for the mangrove swamps of Nigeria.

[25] The *tasquero*, a small red crab (*Pachygrapus cruentatus*) is the more abundant of the crustaceans in the mangrove. The scurrying of these brilliantly colored animals up and down the prop roots of *Rhizophora* and across mud flats is one of the common sights in the mangrove forest. A much larger, edible crab (unidentified) is also found along the muddy banks of the esteros.

[26] Freise, *op. cit.*, pp. 345–346, has conducted experiments on the rate of decomposition of oyster and clam shells fixed on mangrove roots along the Brazilian coast. *Rhizophora* quickly absorbs the calcium carbonate through the prop roots.

Although black mud and peat comprise most of the soils of the mangrove swamp, small spots of sandy material occur. Within the swamp back from the seacoast for a distance of one-half to one mile, one frequently encounters along tidal channels small areas of sandy soil which rise slightly above the general level of the swampy muck. These sandy spots are locally called *firmes*. They are sites of human habitation within the mangrove swamp; freshwater is usually found at a depth of three to four feet below the surface; and coconut palms, patches of maize, and other crops are grown. Some of these firmes appear to be remnants of old beach ridges that have been largely destroyed with the general seaward advance of the coast. Others, farther inland, may be the remnants of natural levees built by former stream channels. The greatest numbers of the firmes along the Colombian coast are found in the extensive mangroves of the Patía-Tapaje-Sanguianga delta system north of Tumaco. There, sizeable villages, such as Mosquera and El Cocal are located on such sandy "islands." Many of the firmes in this area and farther south toward the Ecuadorean border contain an abundance of highly weathered potsherds, indicating the presence of pre-Columbian Indian sites within the mangrove. Moreover, today much of the coconut production of the coast of Nariño comes from small groves planted on the firmes.

RELATION OF MANGROVE TO SHORE PROGRADATION

It is commonly stated that mangrove, and in particular *Rhizophora*, is an important agent in the seaward advance of low tropical coastlines.[27] It is supposed that *Rhizophora* is the pioneer colonizer of partially submerged mud banks and shoals, that the growth of young plants fixes the shoal, and that the later development of prop roots is instrumental in entrapping sediments carried by tidal currents, thus aiding in the advance of the shoreline. Consequently, *Rhizophora* is often termed "land-builder," or "mother of islands." This function of young mangrove has been overemphasized and cannot be said to occur universally. It is probably true that the prop roots of mature *Rhizophora* serve to catch some fine particles carried by tidal currents and thus aid in deposition; however, the electrolitic precipitation of suspended materials in river water on contact with salt water is possibly of greater importance as a cause of deposition of fine particles within the mangrove section of the coast.[28] Along the Colombian coast and elsewhere it is observed that land must be entirely emerged before it is colonized by mangrove, that the first colonizers are often not *Rhizophora* but black mangrove (*Avicennia*),

[27] See, for example, statements made by T. W. Vaughn, "The Geologic Work of Mangrove in Southern Florida," *Smithsonian Institution, Miscellaneous Coll.*, Vol. LII (1910), pp. 461–464; R. Erichson, "Die Mangrove-Vegetation," *Natur*, Vol. XVI (1925), pp. 190–199; V. J. Chapman, "The Botany of the Jamaican Shoreline," *Geographical Journal*, Vol. XCVI (1940), pp. 312–323; J. H. Davis, "The Ecology and Geologic Role of Mangroves . . . ," *op. cit.*, 394–405; J. H. Davis, "Mangroves, Makers of Lands," *Nature Magazine*, Vol. XXXI (1938), pp. 551–553.

[28] G. von Freyberg, "Zerstörung und Sedimentation an der Mangrovküste Brasiliens," *Leopoldina*, Vol. VI (1930), pp. 69–117, ref. pp. 109–110; Grewe, *op. cit.*, p. 119.

and that *Rhizophora* will not establish or even maintain itself except in quiet saline to brackish water in sheltered bays or along coastlines protected from wave action by offshore bars or shoals.[29] *Avicennia* is usually the first mangrove plant to invade lagoons immediately back of newly formed beaches; it appears to be more tolerant of highly saline sea water than is *Rhizophora;* moreover, *Avicennia* can establish itself in soil having large amounts of coarse quartz sand, whereas *Rhizophora* demands mud of finely divided particles of high organic content for full development.[30] In any case the preference of mangrove for fine sediment, be it *Rhizophora* or *Avicennia,* tends to localize these plants in those areas that would experience vigorous alluviation regardless of the plant cover; vegetation would seem to play a minor role in progradation of shorelines.

Mud flats along the Colombian coast are not colonized gradually by mangrove; the term "walking out to sea," often applied to the growth of *Rhizophora* outward from a mother stand, probably does not occur, except perhaps along the sides of tidal channels. Rather, seaward advance of mangrove on tidal flats seems to occur suddenly with the chance transport of floating masses of seeds by irregular tidal currents to a flat, where they are stranded at low tide. If undisturbed by subsequent current and wave action, the seedlings may become established as a colony, all plants of which are of a single age group. As the plants mature, the entire colony maintains an even height. Thus, along those parts of the Colombian coast where mangrove fronts directly on the sea, a step-like vegetational profile develops landward, each "step" representing a plant colony of a given age group. Once a colony of *Rhizophora* is established, young plants develop within it only occasionally. Moreover, the seaward edge of the colony is usually cut by waves to form a sharp vegetational "bluff," a feature which appears to be typical of mangroves the world over.[31] (Fig. 11).

Despite the solid appearance of the large prop roots of mature *Rhizophora* and the matted root system of *Avicennia,* forests of both are easily driven back by strong wave action. Constant shifting or destruction of mud shoals and offshore

[29] This situation has been described for the coast of Brazil between Belem and São Luis by von Freyberg, *op cit.,* p. 109; for Malaya by Watson, *op. cit.,* pp. 1, 5; for British Guiana by Martyn, *op. cit.,* p. 293. C. G. G. J. van Steenis, "Kustaanwas en mangrove," *Natuurwetenschappelijk Tidjschrift voor Nederlandsch Indië,* Vol. CI (1941), pp. 82–85, states that from data in the literature and from his own observations in Sumatra, natural coastal accretion by mud-silting is the factor responsible for the development of the mangrove, not vice-versa. A similar view was held earlier, in 1890, by B. Hagen, "Die Pflanzen- und Thierwelt von Deli auf der Ostküste Sumatra," *Tidjschrift van het Kon. Nederlandsch Aardijksundig Genootschap,* 2nd. ser, Vol. VII (1890), pp. 1–240, ref., p. 21.

[30] Watson, *op cit.,* p. 56, speaking of mangrove along the coasts of Malaya, suggests that *Avicennia,* by supplying raw alluvium with organic material through root decay prepares the soil for invasion by more exacting mangrove, such as *Rhizophora.* Furthermore, the small pneumatophores of *Avicennia* aid in catching the floating *Rhizophora* hypocotyls, which quickly take root in the mud. On the other hand, Davis, "The Ecology and Geologic Role of Mangroves . . . ," pp. 322–331, has shown that in southern Florida *Rhizophora* pioneers mud flats, while *Avicennia, Laguncularia,* and *Conocarpus* form successive bands inland.

[31] Egler, "The Dispersal and Establishment of Red Mangrove . . . ," *op. cit.,* p. 305.

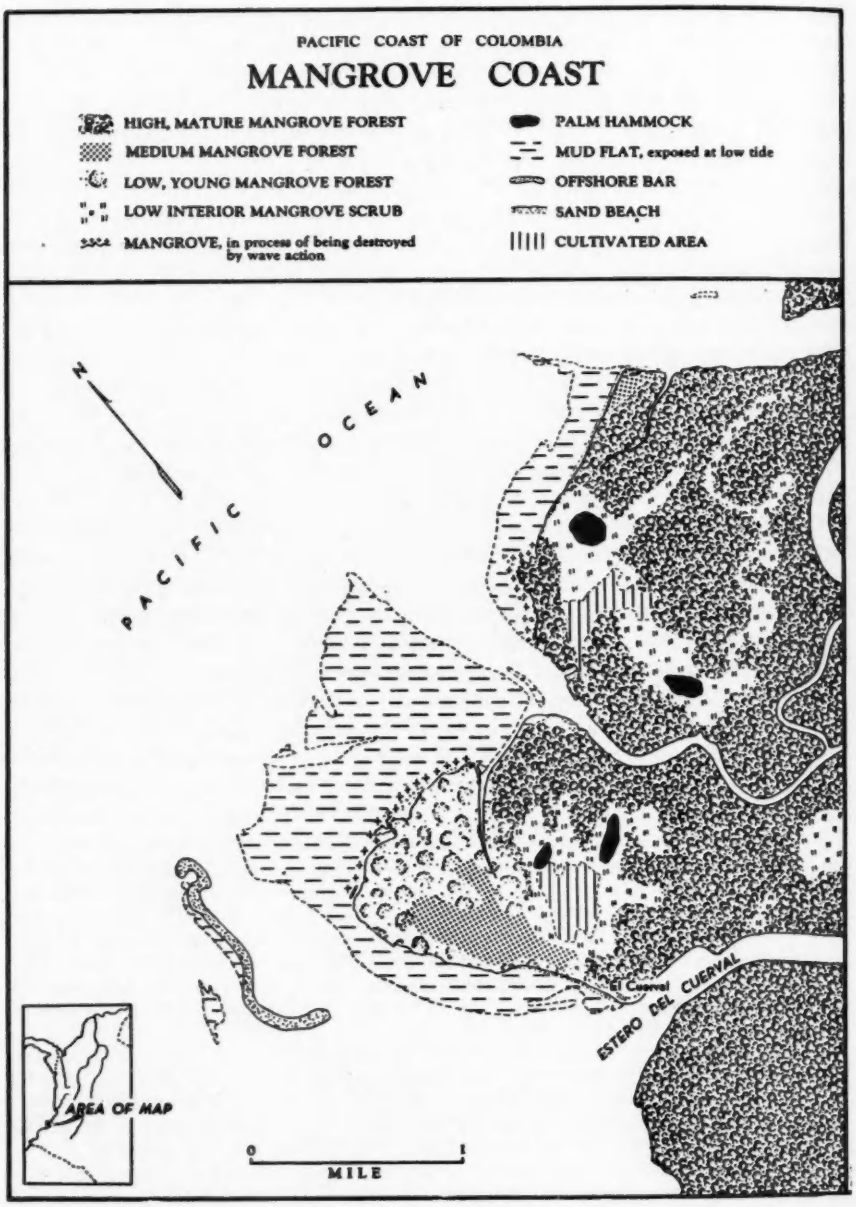


FIG. 11. A portion of the mangrove coast of Colombia, showing the shoal area, composed of mud flats and offshore bars, narrow beaches, and the mangrove forest. The low, medium, and high forest areas represent mangrove of different age groups. Waves have eaten into one of the interior spots of low vegetation. Drawn from aerial photo.

bars causes continual change of the locale of wave action along mangrove-bordered bays and estuaries. At such points waves immediately begin to erode the muck and underlying peat which support mature mangrove, eventually killing extensive areas of *Rhizophora* and *Avicennia* forest.[32] Furthermore, the deposition of sand in stands of *Rhizophora* soon kills the mature trees. Sediment of nearly pure quartz sand apparently contains insufficient nutrients for the maintenance of that species. A common sight at many points along the Colombian Pacific coast is the presence of a newly-formed beach along the outer edge of mangrove with bare,

FIG. 12. Mangrove forest being destroyed by wave action along coast north of San Juan Delta. The soil that develops beneath the mature mangrove is peat-like and spongy.

grey branches of dead giant *Rhizophora* silhouetted against the green forest in the background (Figs. 12, 13).

Like most low, alluvial coasts, the mangrove littoral of Colombia is unstable; the coastline is in continual flux, one section now retreating, another advancing. Despite its instability, in general, the coast appears to be advancing, as evidenced by remnants of beaches (*firmes*) in the present mangrove belt. Owing to the lack of historical data, determination of the rate of advance is not possible, but it has

[32] Similar effects of wave erosion on mangrove vegetation have been described for the coast of Brazil by von Freyberg, *op. cit.*, p. 109.

probably been extremely slow; certainly it is not comparable to the rapid advance of the delta mangrove shorelines of southeast Asia, where wave and current action is much less and stream load is much greater.[33]

THE FRESH-WATER SWAMP ZONE

Landward from the mangrove lies a belt of fresh-water swamp, one-half to two miles wide. Incoming tide causes fresh or slightly brackish water to back up in

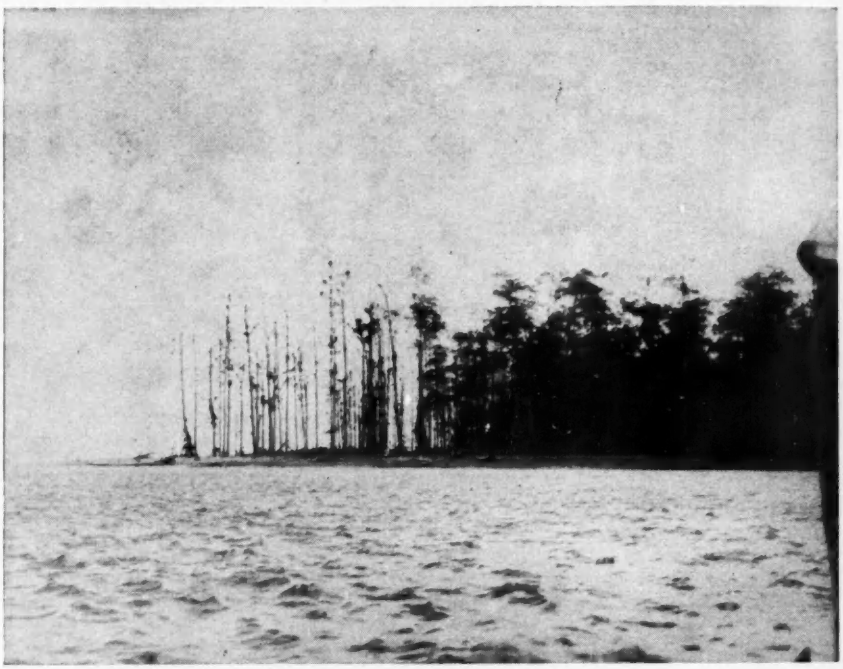


FIG. 13. Mangrove forest being destroyed by deposition of sand beach, near Togoramá, San Juan Delta.

the lower stream courses and to overflow their banks, inundating extensive areas of low-lying land twice each 24-hour period. Like the mangrove, the fresh-water swamp penetrates inland for some distance upstream along the banks of rivers strongly affected by tide.

[33] An account written in 1790 by a Spanish naval officer specifies that Gallo Island, north of Tumaco, was separated from the mainland by a narrow tidal channel, indicating that little change has occurred in that portion of the coast in the last 160 years. Alejandro Malaspina, "Navegación frente a las Costas de Cauca y Panamá, año de 1790," in Antonio B. Cuervo (ed.) *Colección de Documentos Inéditos Sobre la Geografía y la Historia de Colombia* (Bogotá, 1891), Vol. II, pp. 129–160, ref., p. 143.

A plant assemblage of comparatively few species composes the vegetation of the fresh-water swamp. Being aggressive plants, they have crowded out the more salt-tolerant mangrove into the brackish and salt-water areas closer to the sea. As the inward edge of the mangrove becomes higher and less saline, the fresh-water plants invade. The most dominant tree of the swamp is the giant *nato* (*Mora megistosperma*). It grows to a height of more than 100 feet and develops huge buttresses at its base. Tolerant of brackish water, the nato often mixes with *Rhizophora* in the inner edge of the mangrove zone. Associated with nato is the

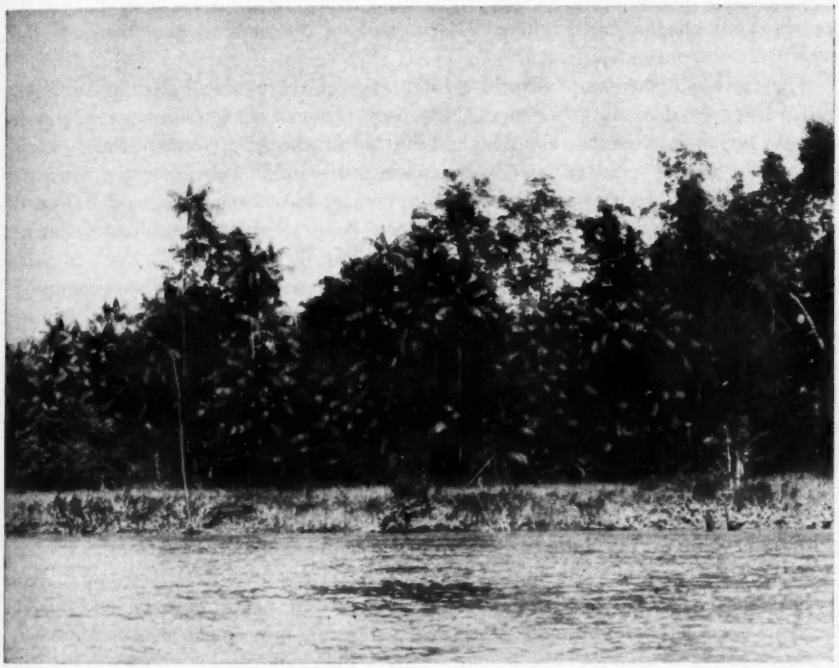


FIG. 14. The naidí palm (*Euterpe*)—nato (*Mora*) association of the fresh-water swamp behind the mangrove, lower Río Guapi. The river bank in the foreground has been cleared for rice cultivation.

graceful *naidí*, or *palmiche*, palm (*Euterpe Cuatrecasana*), which grows in clumps on the higher, drier spots, such as along the low stream levees or on levee remnants in the interior (Fig. 14). Another typical associate is the *manguillo* (*Tovomita rhizophoriodes*), a large, prop-rooted tree. Two large trees often form solid stands in the less brackish portions of the swamp: the *sajo* (*Campnosperma panamensis*) and *cuángare* (*Virola* spp.). The latter is now being logged in substantial amounts in the vicinity of Tumaco. A small but conspicuous stream-bank tree is a bombax called *sapotelongo*, or *bambudo* (*Pachira aquatica*), which drops its

large, round seed pods into the water with a resounding splash. The low stream banks are also covered by many types of grasses. Two of these, *pará* (*Panicum barbinode*) and *arrocillo* (*Oriza latifolia*), introduced in the last fifty years, have gone wild. The former is present especially in the swamp areas in the lower Patía, Mira, and Mataje rivers, near the Ecuadorian border, where numerous attempts have been made to establish small pastures farther upstream; elsewhere it may have been transported by streams from headwater areas on the Pacific slope of the Cordillera Occidental, where Antioqueño colonists have established pastures. *Arrocillo* is probably an accidental introduction with rice cultivation. Today both grasses occur chiefly on abandoned clearings along the main stream banks in the swamps.

The fresh-water swamp affords greater ease of travel and better possibilities for food supply than the mangrove. The prop roots of *Rhizophora* and the soft, brackish muck are absent. Yet the semi-diurnal flooding by river overflow makes most of the swamp penetrable only by canoe during high tide. During the past twenty-five years Negroes and Indians from upriver have been utilizing the flooded river banks for growing rice. This development has lessened the problem of obtaining food within the coastal area.

Although malaria occurs throughout the Pacific coast, the *Anopheles* mosquito prevails in the fresh-water swamp zone. Pools of standing fresh water, left by the retreating tide, form excellent breeding places for these insects. At dusk and at dawn swarms of mosquitoes and other biting insects (mainly black flies and gnats) occur around every hut and canoe to pester unprotected occupants to distraction.

FAUNA OF THE TIDAL FORESTS

Although in general animal life in the mangrove and adjacent fresh-water swamp is relatively sparce, waterfowl and shellfish abound. Mention has been made of the large blue crabs, hunted by all who travel through the mangroves. Of the larger animals the most abundant is the iguana, a large tropical lizard that grows to three feet in length. Living in the trees and feeding on birds, eggs, and tender leaves, this reptile dives into the water with a resounding splash on the approach of a canoe. His white, tender meat makes a delicious meal, and he is eagerly sought by canoemen as they paddle slowly along the tidal channels. Droves of red howler monkeys sometimes penetrate into the remoter sections of the swamp to feed on crabs, and occasionally the small brocket deer (*Mazama* spp.) is found in the drier parts of the mangrove. The wise traveler, however, sees that his canoe is well stocked with food and water before making long journeys into the swamps.

EXPLOITATION OF THE TIDAL FORESTS

Within the last forty years many Negroid inhabitants of the upstream areas have entered the tidal swamps to exploit various forest products. The most lucrative activity has been the collection of bark from the giant red mangrove (*Rhizophora*), the value of which arises from its fifty to sixty percent content of tannin,

used in the leather industry. The bark collectors have established many *concheras*, or temporary camps on the *firmes* and along tidal channels within the swamp, where, amidst the evil stink and swarms of insects, bark is stored and sold to traveling buyers. To strip its bark a tree must be felled; thus considerable destruction of the high mangrove has occurred in many areas along the coast. Most of the bark collected is taken to Buenaventura, where a single plant manufactures tannin extract.

The large red mangrove trees are little used for lumber, though some are cut for railroad ties. A more significant use of the wood is for making charcoal, consumed in large quantities as the common household fuel in the larger coastal towns, such as Buenaventura, Tumaco, and Guapi. To furnish sufficient wood for the numerous kilns, much of the mangrove forest around such centers is being depleted of its larger trees. Destructive exploitation of the Colombian mangroves, however, is still insignificant when compared to the enormous depletion that has taken place in tidal forests of East Africa and parts of southeastern Asia.

In terms of economic value the fresh-water swamp behind the mangrove is becoming the most significant part of the tidal forests of Colombia. As indicated earlier, this area is coming to be an important producer of rice, a development that has occurred in fresh-water tidal swamps in other tropical regions. Moreover, in recent years lumbering of the large tropical softwoods, such as the giant *nato* (*Megistosperma*) and *cuángare* (*Virola*) has increased. The fact that such species grow in almost solid stands decreases logging costs. Logs are rafted to various sawmills along the mangrove coast; six mills operate in Buenaventura, the lumber and shipping center of the Colombian Pacific coast. From there *Virola* logs are shipped directly to Europe, while most of the sawed lumber is taken by rail or truck to the growing industrial center of Cali and other inland points.

CONCLUSION

Although the mangrove swamps of the Colombian Pacific littoral are still imperfectly known botanically and ecologically, observations made on reconnaissance indicate that many morphological features are common to tidal swamps along other tropical coasts. The belted arrangement of species, though imperfect in Colombia, appears to hold; the presence of the circular patches of low growth in the interior of the swamp is another common feature of mangrove development; the coastwise arrangement of geographical zones, such as the sequence of shoal, beach, mangrove, and fresh-water swamp, occurs along most low alluvial coasts of the humid tropics. On the other hand, mangrove as a geologic agent in coastal progradation appears to be unimportant along the Colombian coast. Other aspects of the Colombian mangrove area, such as travel, subsistence, and economic development, seem to be similar to those of other tidal swamps of the tropics. Further field observation and examination of aerial photographs of low tropical coasts on a world-wide basis is necessary for a more thorough geographical analysis of mangrove forests.

CULTURAL FACTORS IN THE LOCATION OF THE SWATOW LACE AND NEEDLEWORK INDUSTRY

THEODORE HERMAN
Colgate University

ONE of the most inviting possibilities in the development of areas of great underemployment is the promotion of handicraft industries. Particularly appealing is production for export, especially to the United States, where high buying power promises volume orders, and the producing country hopes thereby to earn ample foreign exchange.

The location of a successful export handicraft industry often represents a choice between enlarging an already-operating center that may be far inland, or setting up a new one close to coastal ports. The former may have the advantages of existing facilities, experienced labor, access to raw materials, and an established finance and marketing organization; the latter is close to exporters, foreign buyers, and ready capital and saves transport costs on the finished products. In actual practice the final location may result in a compromise somewhere between an inland and a coastal area.

THE SWATOW CENTER, 1917–49

This paper analyzes such an unplanned compromise location that grew in response to five internal and external factors operating at a given period of cross-cultural contact. The illustration is the great export lace and needlework (including drawn-work) industry that flourished around Swatow on the southeast coast of China from 1917 to 1949 (see Fig. 1).

The five factors on which the commercial industry in the area grew and that account for its diffused pattern are as follows:

1) The prior existence of a traditional center of fine needlework at Ch'aoan.

2) A period of dynastic decay and hence great need by the people to supplement their income, a condition intensified by the presence of thousands of women and girls able to perform with skill, speed, and accuracy.

3) The arrival of Western missionaries who taught Western lace and needlework as a self-help enterprise to their converts.

4) The preference of women in the social conditions of the early 20th century to work part-time in their village homes instead of full-time in workshops in the port city.

5) Expansion of the craft on a commercial basis during World War I by Western and Chinese exporters who had complete control of production through their agents' distributing raw materials and collecting finished products.

The exact circumstances of the choice of Swatow as a center during and after World War I are not known. Today the city has become the major port in a

small coastal delta of 600 square miles formed where the Han and T'o Rivers enter the South China Sea, some 170 miles northeast of Hong Kong. Long before northeastern Kwangtung was opened to foreign residence and commerce in 1858,

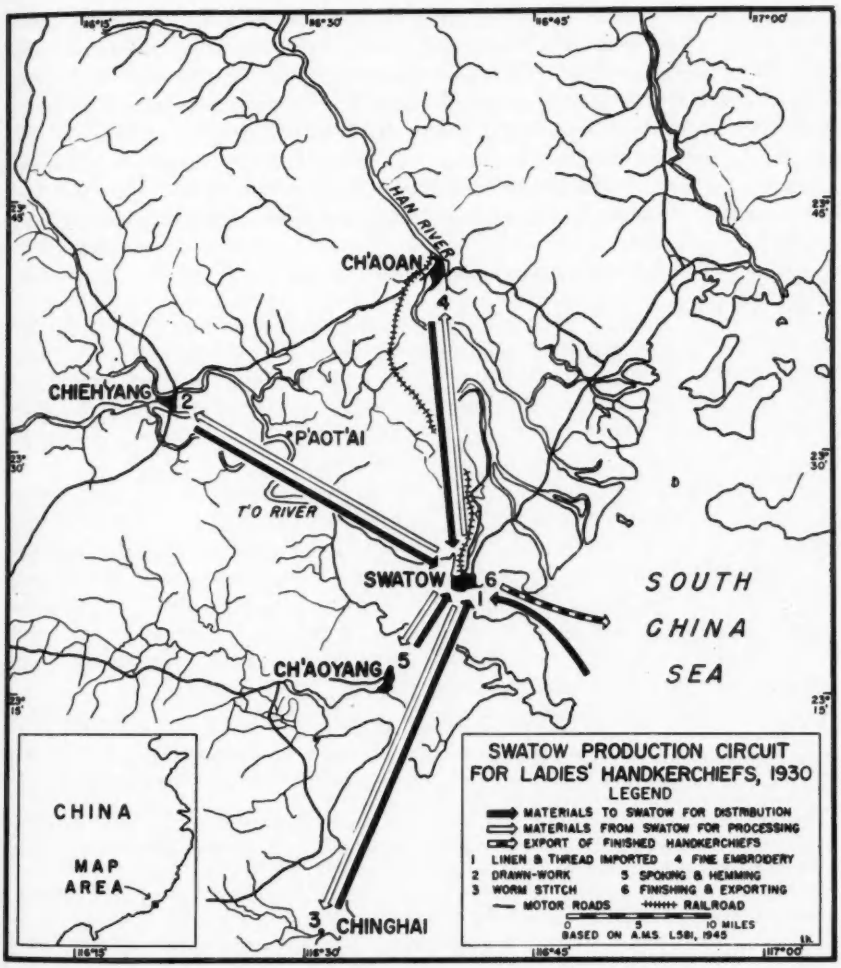


FIG. 1

Ch'aochowfu (now Ch'aoan), 25 miles north and inland on the Han River, was the leading port and administrative center. A comparison of estimated populations made in 1901 placed Ch'aochowfu at 500,000 and Swatow at only 40,000–

50,000.[1] In more recent years, estimates show 300,000 for Ch'aoan and 178,000 for Swatow in 1931. Part of Swatow's growth can be attributed to the trade generated by the export lace and needlework industry that arose in its hinterland.

Western-style lace and needlework had been made earlier around other coastal ports, as well as Swatow, several of them being more regularly visited by ocean-going ships. The development of commercial production around Swatow may have started when a foreign dealer was approached by a local missionary seeking a larger outlet for the pieces made by his or her converts, or perhaps a dealer traced back to Swatow the source of pieces that looked European. There are several possibilities, but the main attraction was undoubtedly the existence of an experienced, low-priced labor force of women and girls, the nucleus of which had been trained by English, and later American, Presbyterian missionaries beginning in 1894.[2]

IMPORTANCE OF THE TRADE

The production of Western-style lace and needlework around Swatow did not become commercially important until after World War I. As with other products —rugs, carpets, hairnets, straw hats—for Western markets, the War interrupted European production, so that both European and American dealers turned to China for such articles. There they found thousands of low-paid workers, intelligent, adept, and not adverse to doing repetitive hand work.

Within ten years, Veretian and other European laces made in the Swatow area had largely supplanted production in European centers, including Venice itself.[3] Swatow hand embroidery forced Swiss workers to shift to machines for medium and low-priced lines, while American machine-made embroidery was steadily undersold even in the protected United States market.[4] From 1924 to 1935 the annual value of lace and needlework exported from Swatow generally exceeded one million dollars (U.S.), f.o.b. Swatow; in 1937 it was over six million.[5] An estimated 300,000 people, mostly women and girls, were employed.[6]

Most Swatow export needlework was for handkerchiefs, with smaller quantities

[1] "Trade Conditions in Swatow," by Vice-Consul Langhorne, Swatow, 1901, in U. S. Department of State, *Commercial Relations of the United States with Foreign Countries, 1901* (Washington, D. C., 1902), Vol. I, pp. 795–796.

[2] Most of the early history of the missionary phase was furnished by Mrs. Anne K. Speicher of Providence, R. I., a member of the American Baptist Foreign Missionary Society in Swatow, 1895–1936, in two personal letters, June 4, 1952, and July 4, 1952.

[3] Report by Consul James B. Young, Venice, Italy, in *Commerce Reports*, U. S. Department of Commerce, Vol. 24 (June 1, 1928), p. 674.

[4] U. S. Tariff Commission, *United States Imports from China* (Washington, D. C., 1945), p. 157.

[5] Compiled from Chinese Maritime Customs, *Returns of Trade* (Shanghai: Inspectorate General of Customs, annually).

[6] A generalized compromise between an estimate of 200,000 in U. S. Department of Commerce, *China Monthly Trade Report*, Feb. 1, 1935, p. 15, and 400,000, a medium estimate by Mr. Fred Maloof, former exporter-importer of Swatow work for 25 years, in a personal interview in New York, April 21, 1952.

for tea sets and runners; some lace was also made, especially for large tablecloths. The bulk of the handkerchiefs, both men's and ladies', were of medium quality but contained a variety of work: drawn-work,[7] embroidery, and a hand-rolled hem. An expensive piece for a lady might also include an embroidered monogram, appliqué, and tiny webs of specially-made lace inserted into openings of various shapes. It was this variety of work, demanding different skills and training localized in particular areas, that marked the circuit over which a piece of plain linen was carried to become a lovely handkerchief. And in response to that circuit, an economic organization developed to tie the scattered producers to remote foreign markets.

CULTURAL FACTORS AND THE PRODUCTION PATTERN

Each of the five factors listed above played a part in attracting the industry to the area and in helping to locate its several features. Fine embroidery was the specialty of Ch'aoan because of geographic-historic circumstances. During the Ming and Ch'ing periods, pirate raids along the coast were frequent, so that Ch'aoan (then Ch'aochowfu), well-upstream from the sea but where the Han River was still deep enough for coastal junks, was the main government center. Here fine classical needlework was developed in the Ming Dynasty for gowns of officials,[8] so that when Western-style embroidery became commercially important, the highly skilled labor attracted such work to Ch'aoan.[9]

When Western businessmen and missionaries widened their contact with China in the second half of the 19th century, economic conditions were steadily deteriorating. It is impossible now to ascertain which region was in the worst condition, but early accounts of Swatow stress that even with two crops of rice, population pressure required rice imports. From here thousands of poor farmers emigrated to Southeast Asia beginning about 1860 as Western enterprise created jobs in mining and commercial agriculture.[10] The excess of women and girls left behind provided a labor reservoir for light industry.

Mission activity began around Swatow in 1850, presumably on a nearby island where English merchants were already operating, and spread inland to Ch'aochowfu in 1888.[11] In 1894, a Mrs. Lyall of the English Presbyterian Mission taught Mexican drawn-work to a girl who needed to earn extra money to complete her education at the mission school, and from this start other girls soon learned. Later,

[7] Drawn-work is made by removing several rows of adjacent threads running in the same direction and binding three or four of the remaining cross threads into a bundle or "spoke" across the altered strip.

[8] *Kwantung T'ung-chih, 1865* (Shanghai: Commercial Press, 1934), pp. 1796 b, 1863 a. In Chinese.

[9] "Drawn-work, Embroidery, and Lace Industries in Swatow District," by Consul M. W. Myers, Swatow, in *Commerce Reports*, U. S. Department of Commerce, Vol. 20 (Jan. 25, 1921), p. 478.

[10] Chen Ta, *Chinese Migrations, with Special Reference to Labor Conditions*, U. S. Department of Labor, Bureau of Labor Statistics, Miscellaneous Series, No. 340 (1923), p. 4.

[11] Milton T. Stauffer, ed., *The Christian Occupation of China* (Shanghai: China Continuation Committee, 1922), App. E.

women came from many inland places for training, some returning home and thus spreading the craft, and some remaining in Swatow after persuading their families to join them. In this early period, local grasscloth was used for the base. Embroidery was added, both in Chinese and introduced designs, and lace-making also spread.

When foreign dealers began to converge on Swatow during World War I they aimed to set up workshops there where they could directly supervise women working full-time. However, this plan did not work out, because of a combination of economic and social conditions. In the putting-out system, the exporters' Chinese agents and local competitors quickly realized that they could get the work done more cheaply in the inland areas where the women and their daughters were living at home. Also, as a feature of the pre-industrial society of the time, the village women preferred to work at their own speed and among their own family members where informality and less routine seemed more desirable than the regularity of supervised factory life. Finally, at home they would not be subject to close contact with strangers, especially men, in a distant community, a factor of considerable importance in many parts of China 40 years ago. Thus, contrary to all "rational" industrial planning, most of the production was carried on outside of Swatow, one center being 30 miles away!

The fifth factor in the diffused location of the industry was the role of the exporters, at first foreign and later joined by Chinese, in controlling production. In this arrangement the market representatives served to extend the production areas, rather than producers creating and building the market. Since the market abroad was culturally remote and constantly changing under strong competition, the pattern differed sharply in this respect from that of some of the traditional Chinese handicrafts where producers or merchant-employers at the site of production controlled both articles and processes of manufacture for traditional, static markets. The former was much more sensitive to change, and in fact prospered on design changes from year to year; the latter suffered under market changes because techniques were preserved by regulations enforced by craft and merchant guilds.

When the foreign dealers began in Swatow it was necessary that each hire a local Chinese *compradore* or production manager to distribute linen, thread, designs, and wages to the workers, and, in turn, to collect the finished products. The exporters had the market contacts, designs, and capital, while the compradores could organize and control the labor force.

After World War I, when supplies again became available, the foreign dealers imported linen from Ireland because it was finer and more regular than Chinese grasscloth.[12] Thread was also imported from England, France, and Japan, since

[12] Most of the information on trade flow and business practice comes from two sources: (1) Mr. Fred Maloof, personal interview, April 21, 1952, and (2) Mr. Irving S. Brown of the U. S. Department of the Treasury, Bureau of Customs, Washington, D. C., in two letters, Nov. 28, 1952, and Feb. 24, 1953. Mr. Brown served with the Chinese Maritime Customs, 1923–1931, and later made several cost studies of the industry around Swatow for the U. S. Bureau of Customs.

it was stronger and more even than that made from Chinese short-staple cotton. The compradore of each exporter distributed the linen and thread to certain villages. For this he had a network of contracted agents, often relatives, who negotiated with the local women workers, collected the finished articles, paid the women, and forwarded the pieces to their head contractors, and so on up the line. Although there was no direct supervision of work in village homes, in principle, responsibility could be enforced at each transfer.

Under this system it was logical that centers which had previously specialized in particular types of work should continue to do so, since the expertness of the local workers was the best guarantee that the imported materials would not be spoiled and that goods would be ready on time. Geographical specialization also increased as the agents took materials back to their own villages where relatives and neighbors could be trusted to do careful work. Articles made under this system commanded a good price abroad because they were made according to designs and standards specified in advance, largely in New York.

THE CIRCUIT OF PRODUCTION

Geographical specialization on certain types of work led to the establishment of an intricate circuit for pieces requiring different treatment. As shown on the map, the area covered spread out 50 miles from north to south, and 30 miles inland. To make ladies' handkerchiefs, pieces of imported linen were stamped with the design in Swatow, often in four copies on a large piece. The agents then carried bundles of the pieces, plus the thread, by launch or sampan up the T'o River to Chiehyang (Kityang), 30 miles west, and its satellite villages, notably P'aot'ai, where women and girls specialized in drawing out the thread for the open borders.

This done, the pieces were collected and returned by the agents to Swatow for inspection, the agents received payment, and the bundles were taken to another area for the next step. If simple worm stitch was required, they went to Chinghai, on the coast 30 miles south of Swatow, where girls of seven or eight were employed. When finished, the pieces again came back to Swatow. For the finest embroidery the material was transferred north to Ch'aoan by river, rail, or road. Upon completion it was again returned to Swatow and sent south to Ch'aoyang for spoking across the drawn-work, cutting the large pieces into four separate handkerchiefs, and hemming by hand—each process done by a different group.

In Swatow, in the workshops of the contractors or exporters, local women did the final processing: inspection, washing, ironing, folding, labelling, and packing. This stage alone employed as many as 5000 women, and normally between 150,000 and 200,000 dozen handkerchiefs were exported annually, 90% to the United States.

Such task specialization represents the assembly-line system and control by exporters carried to the extreme. Costs were kept low by using labor in rural areas where it was abundant and cheap, and no buildings had to be erected. Also, such scattered labor had no craft tradition to be maintained by a guild, nor fair-wage protection guaranteed by law.

While the whole middleman apparatus seems cumbersome, it produced in quantity and with extreme sensitivity to constant changes in design. There can be little doubt that it was an overhead cost that might have been considerably reduced had production been completely centered in one area such as Swatow or even Ch'aoan. However, the scattered production did bring income into inland communities, and the actual fact that trained women were readily available, even though they were scattered, was the chief reason for attracting the industry in the first place. The dealers were spared the costs of training, wasted materials, and the tieing up of capital during the early period.

It is hardly possible to estimate the cost of such initiation. One former Swatow needlework dealer informed me recently that a certain government in Asia had invited him to start his business anew in that country. He requested a ten-year exclusive franchise in order to regain his training investment and be assured that his designs would not be copied and workers lured away by rivals, both foreign and indigenous; in addition, of course, he was anxious to maintain his large marketing organization in the United States.

Since World War II, governments in Asia have moved increasingly to promote and participate in handicraft exports. For the most part the government function has been to improve existing production and to widen foreign markets by displays and advertising, leaving to private businessmen, both their own nationals and foreigners, the actual conduct of business.

At the same time there has been an increase in official concern for the welfare of workers: economic—through labor laws and cooperatives—and social—through education, health, and political participation. It is thus possible that as a step in increasing employment in any particular area chosen by the government, such industry would be an additional factor in location planning. This support would add one more variable of considerable significance in the success of the industry and hence in regional development.

INFLUENCE OF UNDERLYING ROCK STRUCTURES ON STREAM COURSES AND VALLEY PROFILES IN THE GEORGIA PIEDMONT*

JAMES F. WOODRUFF AND ELDON J. PARIZEK
University of Georgia

IT has been generally accepted that Piedmont streams show a striking dissociation with lithology. Fenneman[1] says that "either the diversity in hardness of the Piedmont rocks is not generally significant, or that structure is too complex to be followed, or the events of morphologic history have caused the streams to disregard it." Studies in the Georgia Piedmont, however, suggest that in actuality the converse of this assumption is true. Lithology and structure strongly influence valley shapes and courses of not only subsequent tributaries, but major Georgia Piedmont streams.

GENERAL FEATURES OF PIEDMONT STREAMS

Georgia's Piedmont, which slopes southeast from the edge of the Blue Ridge to the inner margin of the coastal plain, is drained by river systems separated by a narrow, irregular divide. Upper Piedmont rivers, notably the Chattahoochee, generally flow southwest into the Gulf of Mexico, while lower Piedmont streams, with the exception of the Flint, drain southeast to the Atlantic Ocean (Fig. 1).

Upper Piedmont streams parallel the strike of underlying rocks, perhaps in accord with trends of ancient fold or fault valleys.[2] Streams that flow southeast to the Atlantic are incised into the Piedmont plateau and their meandering courses are interrupted by shoals. This drainage was undoubtedly consequent upon the summit slope and transects the rock strike.

The "Carolina complex"[3] of probable Precambrian age is widespread and sig-

* The authors gratefully acknowledge the financial support received from the General Research Fund of the University of Georgia.

[1] Nevin Fenneman, *Physiography of the Eastern United States* (New York: McGraw Hill Book Company, 1938), p. 124.

[2] Marius R. Campbell, "Drainage Modifications and Their Interpretations," *Journal of Geology*, Vol. 4, No. 6 Pt. 2 (1896), p. 676. Campbell says the courses of ". . . a series of streams on the eastern side of the Blue Ridge, appear to have been determined by the depression which preceded and made possible . . . the Chattahoochee River above Columbus, the Savannah above Tallulah Falls, the French Broad above Asheville, and the upper portions of the Catawba and Yadkin [which] occupy almost continuously a line from the margin of the Cretaceous sediments of the Gulf coast to the Triassic deposits of the Dan River area. . . . such an arrangement could have been brought about by a subsidence the axis of which corresponds to the present drainage lines."

[3] This complex was named the "Carolina gneiss" by Arthur Keith in 1901 and includes prominent granites, granodiorites, schists, amphibolites and quartzites. While the term "Carolina" is not used uniformly in all states where these rocks occur, for convenience we have adopted it to unify a lithologically diverse group.

nificant among the diverse igneous and metamorphic rocks traversed by Piedmont streams. Equally important granite rocks,[4] also believed to be Precambrian, are

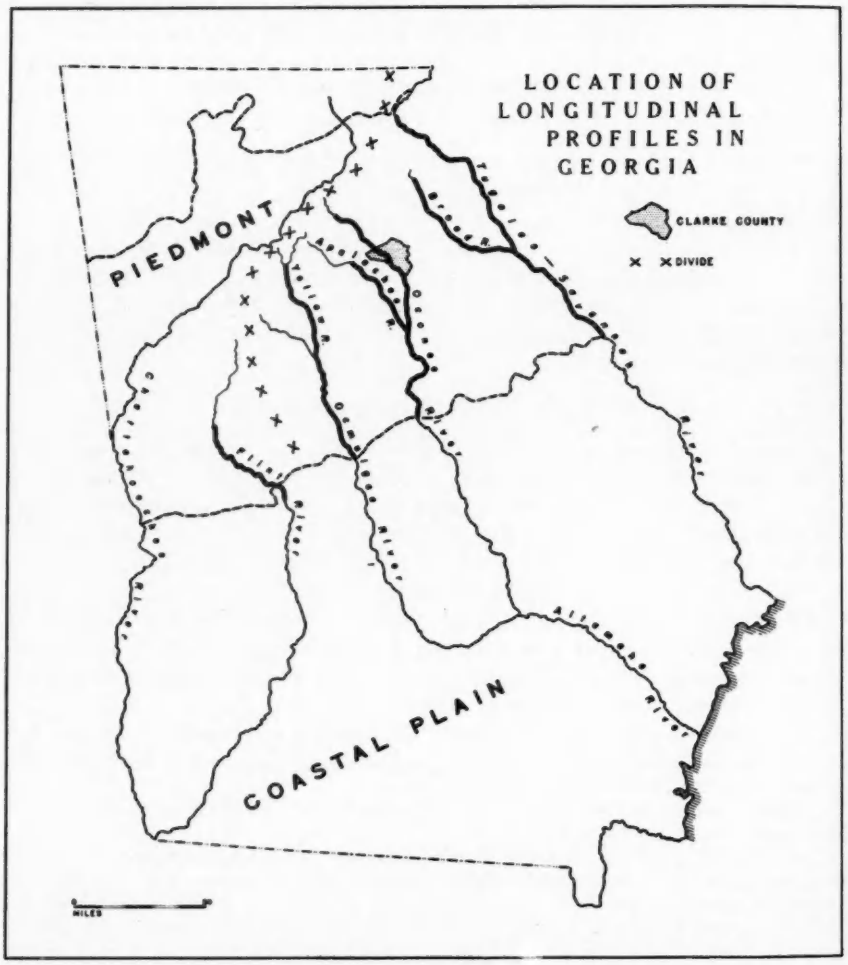


FIG. 1. The heavy lines represent those portions of major Piedmont streams for which longitudinal profiles have been plotted.

[4] Petrographically, the intrusive rocks range from granites to granodiorites and monzonites. In the area thus far studied monzonites are most prevalent, and invariably the periphery is marked by a migmatite. This peripheral contact phase of the intrusion is a mixed rock produced by intimate interfingering of magma and the invaded rock. Most characteristic of the marginal migmatites are well-defined bands which are generally contorted or swirled.

intruded into this complex (Fig. 2). Field studies, particularly in the area drained by the Upper Oconee River, indicate that this lithology and geologic structure now control the present stream courses, and initial extension of the investigations into watersheds of other Piedmont streams tends to substantiate this conclusion.

CONTROL OF LONG PROFILES

Longitudinal profiles of the six principal southeast-flowing streams have been plotted from exact water level data (Fig. 1).[5] The profiles extend from near the headwaters to the Fall Line or to their confluence with another stream. The long profiles (Fig. 3) show the usual concave upward exponential curve, with maximum curvature upstream from the Fall Line in the area of Piedmont crystallines. As

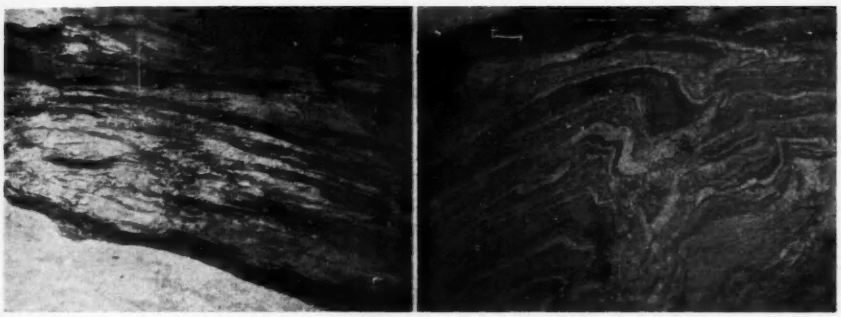


FIG. 2. These photographs show the appearance of two rock types significant to stream development in the Piedmont. The left-hand picture illustrates the platy to fragmented character of the "Carolina" gneiss near the contact with intrusive monzonite. The right-hand picture is representative of the contorted bands and cohesiveness of the migmatite phase of the intrusion.

shown by the Apalachee and Flint River profiles, the most pronounced curvature is along the shorter streams, probably reflecting smaller volumes.

None of the profiles indicate a condition of equilibrium along the full length of the stream, but rather, they are broken into a series of short curves developed above temporary nick points. For example, the Savannah-Tugaloo profile is broken into four broad steps, while the Apalachee has but two curves, of which only the lower is a well-developed curve of equilibrium.[6]

[5] B. M. Hall and M. R. Hall, *Water Resources of Georgia* (Washington, D. C.: Department of the Interior, United States Geological Survey, 1907).

[6] No hypothetical curve of equilibrium was developed for these streams as volume, load, and friction factors are so immeasureable and subject to wide fluctuations that the validity of such curves is dubious. As T. T. Quirke has concluded, *Journal of Geology,* Vol. 53 (1945), p. 130, "The whole attempt to relate capacity (as defined by Gilbert) to the measured velocity of a stream or to the discharge of a trough is fraught with frustrations." Woodford, *Bulletin of the Geological Society of America,* Vol. 62, No. 7 (1951), p. 811, also states: "The best geological test of capacity is the pragmatic one. If a stream has built a deposit, it was loaded and overloaded at some time along that particular stretch with debris of some size and shapes."

In general, high points on the profiles and resulting shoals occur where resistant migmatite and monzonite have pierced the widespread "Carolina rocks," or where resistant facies of the "Carolina" have been exposed by streams. Transverse profiles also reflect the influence of this lithology. At nick points the valleys narrow and are youthful, whereas upstream from the temporary base levels meandering has produced broad flat valleys. Invariably these flats are formed in the less resistant facies of the "Carolina" series. Recurrent along the mature valley walls are two erosional terraces that are probably unrelated to lithology, but may reflect fluctuations of marine shore lines, discharge, or headwater elevations.

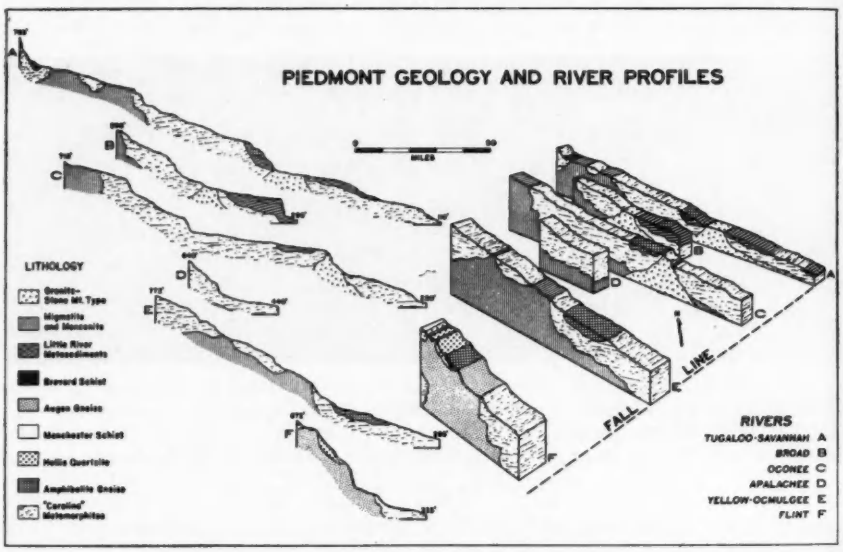


FIG. 3

Finally, these longitudinal profiles exhibit abnormal convexity which traverses several lithologic types in a number of localities, particularly in the lower Tugaloo-Savannah, the upper Broad, the lower Oconee, and two-thirds of the Yellow-Ocmulgee profiles. The convexity, like the erosional terraces, may tend to substantiate the warping postulated in the Piedmont.[7] But in any case it is apparently not lithological.

STRUCTURAL CONTROL OF THE OCONEE RIVER

A more detailed examination of one of the southeast streams, the Oconee, verifies and elaborates upon the general conclusions drawn from the previous profiles (Fig. 1). One of the two branches of the Upper Oconee, the Middle Oconee,

[7] L. LaForge, "Physical Geography of Georgia," *Georgia Geological Survey, Bulletin No. 42* (Atlanta, 1925), p. 91.

drops 196 feet in its 25-mile traverse of Clarke County (Fig. 4). Along this course there are three well-developed shoals, definitely resulting from lithology. The 48-foot drop at Tallassee Shoals is the result of river contact with an extremely resistant facies of the "Carolina,"[8] encountered when the river lowered itself onto the west limb of a faulted south-plunging anticline. Both the small 27-foot Mitchell Shoals and the large 52-foot fall at Barnett Shoals are formed by the migmatite phase of the intrusive monzonite. These three shoals account for 126

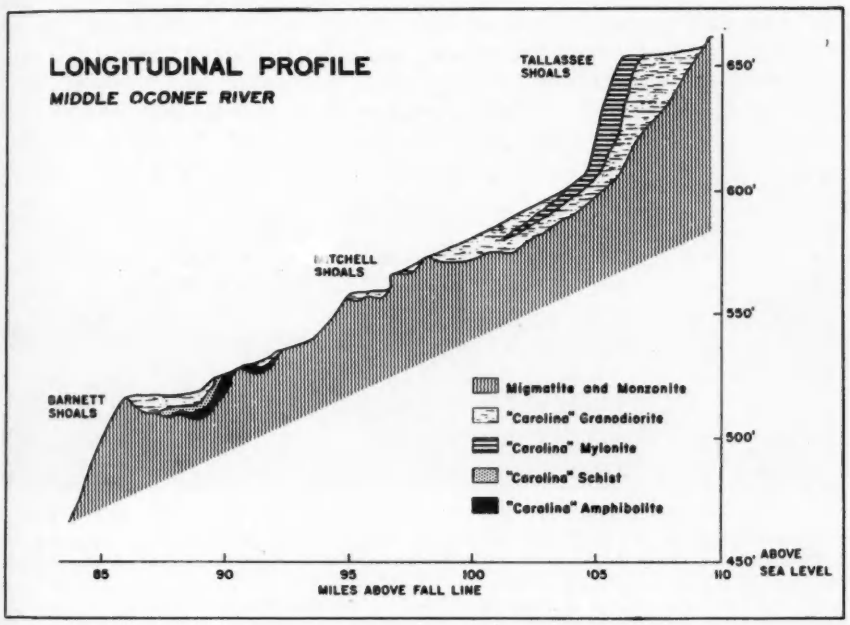


FIG. 4

feet of the total drop while outcropping along only 6.6 miles of the course; and although the average gradient of this 25-mile portion of the Middle Oconee is 7.5 feet per mile, actually the gradient varies from a maximum of 22.5 feet per mile to as little as 0.74 feet per mile.

Such wide variations in gradient are reflected in stream competence and valley shape (Fig. 5). As is characteristic of most Piedmont streams, the valley of the Oconee varies greatly in width. Where the river shoals at nick points, the valley

[8] This facies of the "Carolina" is granitic mylonite, a strongly coherent, fine-grained laminated rock formed by extreme crushing and milling during movements along fault surfaces. By virtue of the high confining pressures under which they originate, mylonites always retain a strongly resistant condition. This facies has been understandably mapped as a quartzite in other regions since its weathered appearance is very similar.

profile is youthful, while upstream from these temporary base levels the meandering river has cut a valley floor more than a mile wide in the softer schists of the "Carolina." The net result is a series of flood plains separated and pinched off from each other by the shoals, and the whole resembles a link-sausage pattern.[9]

Although slope of the summit surface originally determined the southeast direction of flow, lithology and structure have become increasingly important in modifying stream courses following incisement. In the western portion of the county the strike of joints and fractures is to the northeast, while in the eastern half the strike has shifted to the northwest. Generally the strike of cleavage and foliation also shifts in the opposite direction from northeast to northwest across the watershed, while the dip is consistently to the south. Flow of the Upper Oconee is essentially parallel to the strike of foliation, rock lineation, and flow structures; the location and confluence of tributaries to the Oconee also indicate strong structural control. Figure 6, particularly the encircled area, shows the accordance between

FIG. 5. The photographs illustrate varying valley development resulting from lithology. The broad valley in the right-hand picture has been laterally cut in the schist facies of the "Carolina" immediately above a shoals. The left-hand photograph is typical of valley shape in the shoal areas.

the strike of linear properties and major stream flow, and the strike of fractures and tributary patterns. Most indicative of fracture control on tributaries is the right-angle confluence in opposition to the general southeast slope of interfluves. Of additional significance is the fact that many tributaries in entering main streams breach undercut walls near apexes of meanders.

The detail of meander lineament of the Upper Oconee also expresses structural control, as illustrated by the diagrams of Figure 7. In the area diagrammed the river flows south, meandering widely on a granitic phase of the "Carolina." The original meanders developed at a higher elevation within less resistant schists, and, following contact with the underlying material, the course of the river was read-

[9] It is suggested that this pinched and widened type of valley might appropriately be termed a *boudin valley*. The term *boudin* is used in geology to describe certain structures or rock features which alternately thicken and thin to resemble a string of sausages, and thus aptly describes the outline of these valleys.

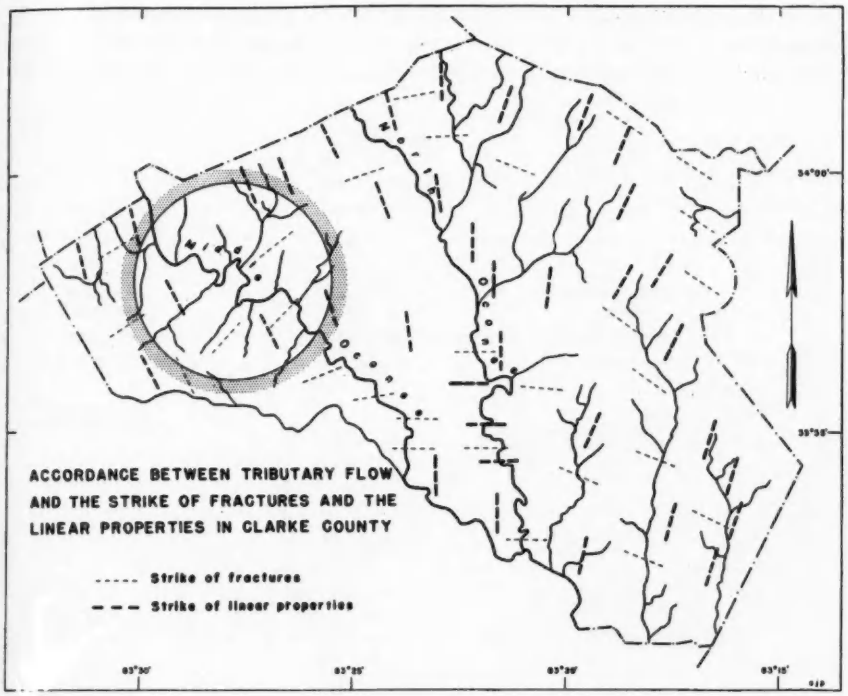

ACCORDANCE BETWEEN TRIBUTARY FLOW
AND THE STRIKE OF FRACTURES AND THE
LINEAR PROPERTIES IN CLARKE COUNTY
Strike of fractures
Strike of linear properties

FIG. 6

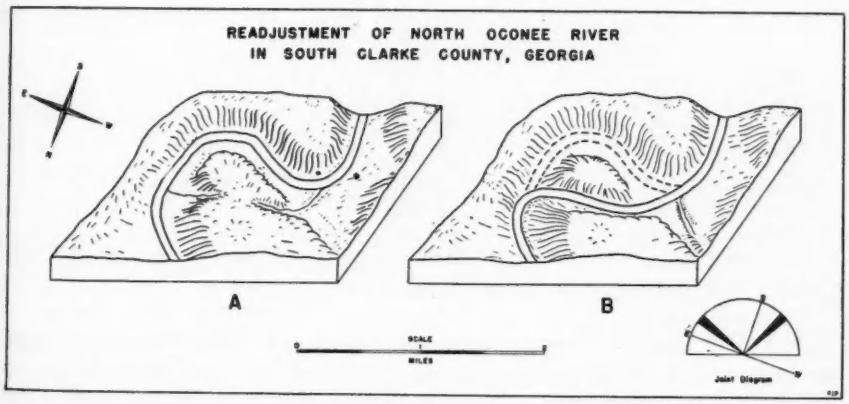

READJUSTMENT OF NORTH OCONEE RIVER
IN SOUTH CLARKE COUNTY, GEORGIA
A
B
SCALE
MILES
Joint Diagram

FIG. 7

justed by intersecting sets of joints in the granite. Although stream flow may be diverted by chute cutoffs, here an outcrop of bedrock between the present river valley and the abandoned meander loop indicates joint rather than depositional

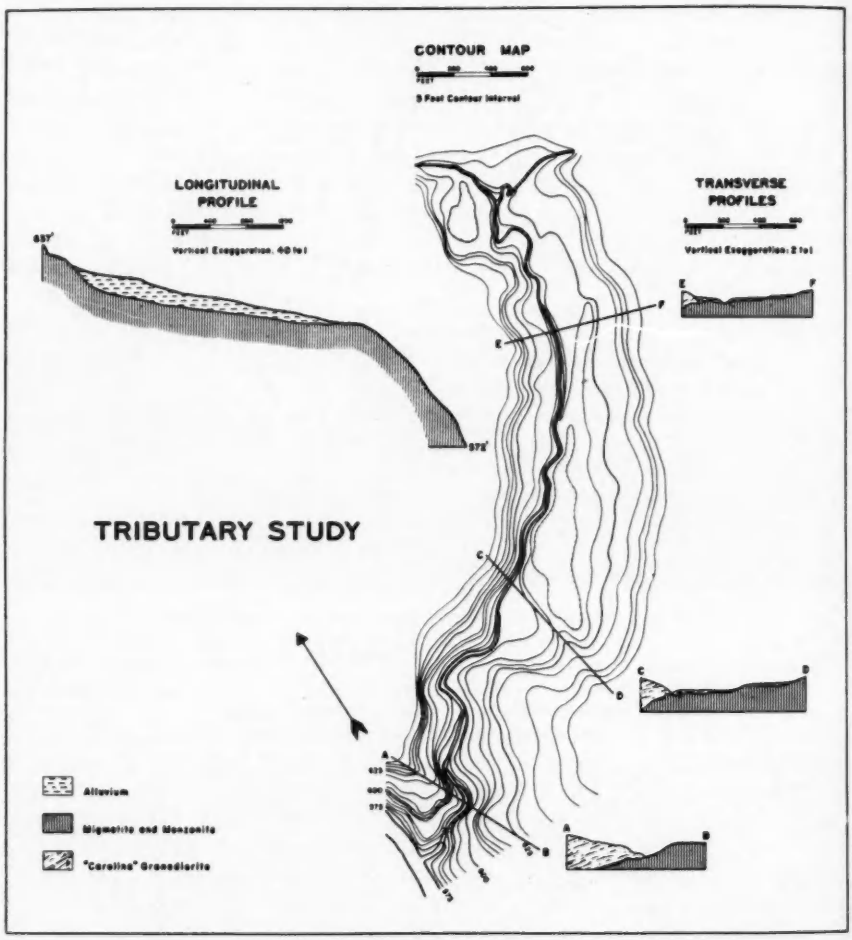


FIG. 8

control of the meander pattern. Apparently one or more tributaries worked along the fractures prior to major stream readjustment, and following headward growth and destruction of the divide produced a channel which was occupied and eroded during flood stages. In time, the complete abandonment of the old meander resulted

in the present highly angular bend.[10] Similar sharp turns along the Oconee River suggest that this is not an isolated instance of joint control on main-stream meanders; moreover, the small tributaries to the major streams show even a greater preponderance of joint-controlled right-angle bends along their courses.

TRIBUTARY STUDY

Study of a small tributary stream corroborates in detail the influence which lithology has had on major stream valleys and also suggests that even rejuvenation

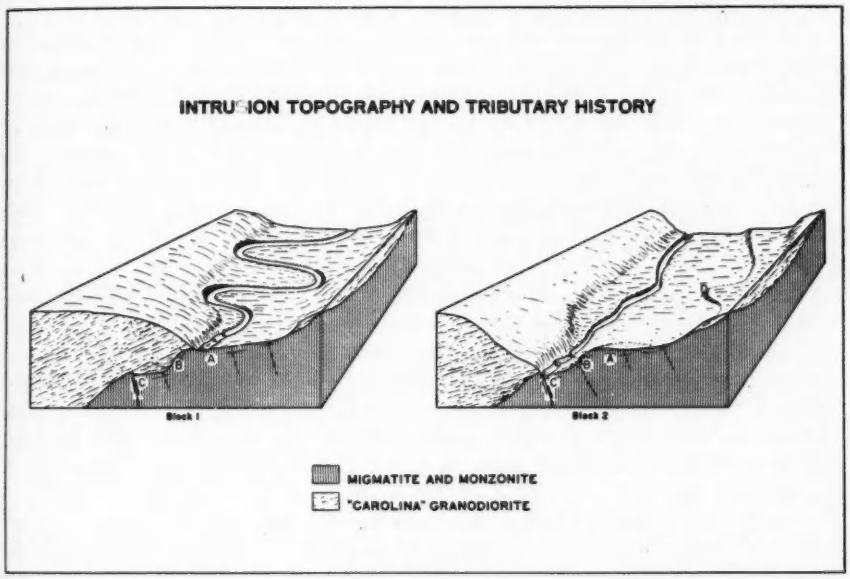


FIG. 9

and terraces in some instances may be so controlled (Fig. 8). The tributary mapped in Figure 8 enters the Middle Oconee at right angles a short distance below Mitchell Shoals, and the observations made are limited to the area between the first and second nick points upstream from the confluence. The northwestern valley wall is cut into the "Carolina" granodiorite, and the contact with the subjacent contorted migmatite is approximately at stream level. The tributary flows along the contact between the two rock types, paralleling rock strike and the trend of linear properties and fractures. The valley floor is veneered with alluvium, and the southeast interfluve roughly outlines the domed shape of the migmatite-monzonite intrusion.

Shoals on the tributary result from contact with the undulating monzonite sur-

[10] E. J. Parizek, "The Influence of Lithology and Structure on the Course of the Upper Oconee River," *Bulletin of the Georgia Academy of Science*, Vol. 12, No. 4 (1954), pp. 10–14.

face. The lower nick point produces a drop of 25 feet as the tributary enters the Middle Oconee, while the upper one separates this valley from the next flat immediately upstream. Retardation of incisement at the lower nick point has resulted in the development of a broad valley floor with an average stream gradient of 7.6 feet per mile.

Width of this valley varies from 40 to more than 600 feet, and the present tributary is entrenched about 6 feet into the northwest edge. Along the southeast margin a discontinuous terrace, particularly well shown by the transverse profiles *C-D* and *E-F*, attests to a former level of the tributary.

While main terraces in tributary valleys may be genetically correlated with those found along major streams, close analysis of geology and valley shape suggests that in some instances tributary terraces have resulted from the topography of the subsurface intrusion. The sketches of Figure 9 illustrate the configuration of the monzonite-migmatite and suggest the history and terrace development of the tributary previously described. The first block shows conditions at an early stage when the tributary had exposed the migmatite, producing a temporary base level. Subsequently, valley widening produced upstream a broad flat in less resistant "Carolina" schists. At this time vertical incisement was retarded, although the gentle slope of the contact between the "Carolina" and migmatite allowed some lateral movement. This slow but continued lateral motion downslope finally exposed the steeper dip of the contact at position *B*, [11] which then promoted rapid incisement and tributary rejuvenation. This incisement was terminated or slowed down as the contact again leveled out between points *B* and *C*. Retardation of downcutting at this new nick point again produced meandering upstream and partial destruction of the former valley flat, as evidenced by erosional terraces (Fig. 9, point *D*).

Final rejuvenation and the present 6-foot entrenchment of the tributary occurred when the stream dropped into a high-angle shear zone after again moving laterally along the contact. Continued lowering of the tributary in the shear zone has subsequently exposed the migmatite at a new point upstream, thus renewing valley widening, which can be expected to destroy and lower the present valley floor. Supporting this postulated sequence of events are the following field observations: (1) the necessary topography of the underlying monzonite-migmatite is partially observable or substantiated by strike and dip of foliation and linear properties; (2) point *A* and the terrace *D* are more than coincidental accordant elevations; and (3) the shear zone at *C*, identified by rock features indicative of stresses,[12] is occupied by the tributary (Fig. 9).

[11] The contact between the granodiorite and migmatite is marked by release fractures and extreme foliation which generally parallel the plane of separation. This zone is also characterized by readily weathered pegmatites, all of which promote ground water movement and chemical decomposition. Streams which breach this zone tend to remain within it, particularly in view of the cohesiveness of the immediately subjacent contorted migmatite.

[12] Mylonites, stretched mineral grains or augen structures, and the polished slickenside appearance in the rocks attest to shear movements in this locality.

CONCLUSIONS

While major Piedmont drainage was originally consequent upon the old southeast-sloping peneplain, following incisement, the underlying lithology and structure have played a refining role in stream characteristics: (1) establishment of a smooth profile of equilibrium has been interrupted and retarded, resulting in widely varying gradients; (2) courses of smaller streams and drainage details are closely controlled by structure and lithology; and (3) resultant valley shapes and terrace development exhibit lithologic and structural influence. These correlations between lithology, structure, and drainage have developed headward into the tributaries to modify and dominate the entire watersheds.

THE UNITED STATES IN PROFESSIONAL GEOGRAPHIC LITERATURE*

H. F. RAUP

Kent State University

WITHIN the thirty-five years from 1920 through 1954, American professional geographers published extensively in four leading periodicals—the *Geographical Review, Journal of Geography, Annals of the Association of American Geographers,* and *Economic Geography.* Other professional publications in which geographic articles appeared included the *Texas Geographic Magazine,* the *Yearbook of the Association of Pacific Coast Geographers, the Bulletin of the Geographical Society of Philadelphia, Landscape,* and others of equal standing. In addition, geographers published many research papers in periodicals such as the quarterly of the Michigan Academy of Arts, Letters, and Science; the journal of the Ohio Academy of Science; the quarterly of the California Historical Society, and similar outlets. To this body of material may be added the mass of published and unpublished research efforts consisting of masters' theses and doctoral dissertations prepared in the centers of graduate instruction in the country.

In an effort to determine what parts of the United States have been investigated most thoroughly by members of the geographic profession in this country, the contents of each publication were noted, and each article or thesis dealing with a particular part of the nation was placed in its appropriate place upon a series of maps.

THE GEOGRAPHICAL REVIEW

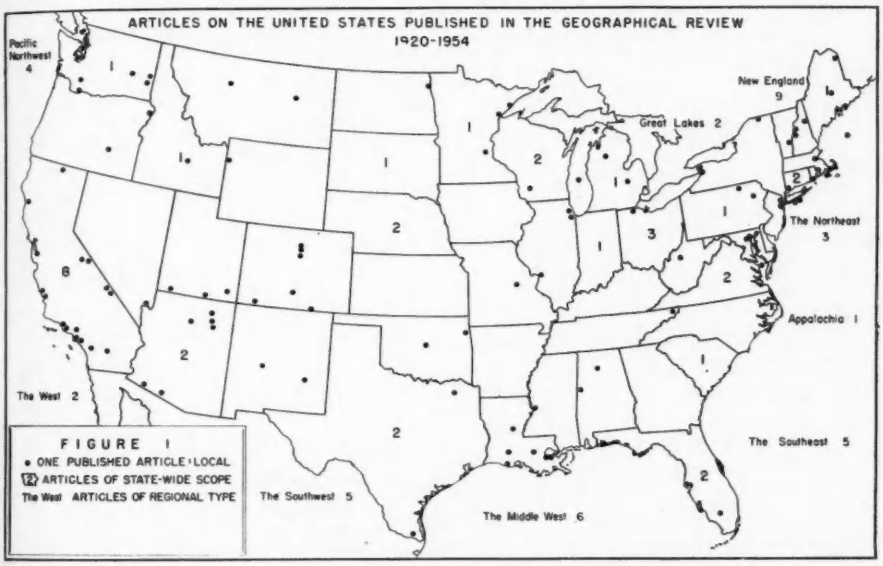
A dot map (Fig. 1) of the geographic distribution of articles on specific places in the United States published in the *Geographical Review* since the beginning of 1920 indicates some emphasis upon the state of California, with sixteen articles; secondary emphasis is upon the New England states, with thirteen articles. Louisiana, Colorado, Arizona, and New York have six articles each on their local geography. For the rest of the country, the distribution is widely scattered, with relative lack of emphasis on the southern and midwestern states. There is no predilection for either urban or rural studies.

Articles in which a single state was used as the basis of the geographic study (represented on the map by numerals within that state) appear most frequently

* Revision of a paper presented at the 51st annual meeting, Association of American Geographers, Memphis, April 13, 1955. I am indebted to Robert Burris, Raymond Hickerson, Douglas McManis, and Michael Senek for assistance in compiling the data presented herein. Though some items may have been overlooked in preparing the maps, the omission of a few articles or theses would not greatly affect the total aspect of the maps and would not invalidate the conclusions of this paper. The study was based solely upon periodical literature and thesis listings; books of a general or regional geographical nature were excluded.

for California (8) and Indiana (3), which together account for one-third of all the articles about states. Regional articles are most numerous for New England and the Middle West. In addition to the articles appearing as dots or figures on the map, the *Geographical Review* published 75 articles between 1920 and 1955 in which the United States as a whole was treated.

A map of this type arouses some questions that are difficult to answer. If, for example, the Middle West has been neglected in the *Geographical Review,* is it because there has been no large or active department of geography within that part of the country to stimulate research at the local or state level? Possibly this part



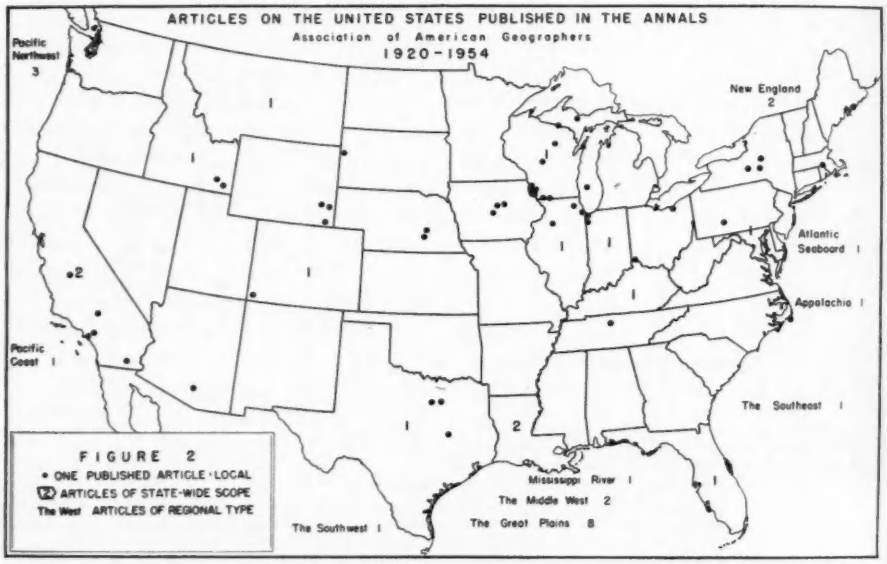
of the nation represents a section of the country in which geographers have had little interest, or less interest than in other sections. It is also possible that the neglect of a given region or over-emphasis on a region may represent the personal bias or interests of the editor. Any one or several of these suggestions might result in the distributional features appearing on Figure 1.

THE ANNALS OF THE ASSOCIATION OF AMERICAN GEOGRAPHERS

The map (Fig. 2) of geographic articles on the United States appearing in the second professional publication, the *Annals of the Association of American Geographers,* displays a smaller number of articles than any of the three other periodicals of Figures 1, 3, and 4. The editorial policy of this quarterly, at least in recent years, has been to accept only papers in which there is an element of originality in treatment, or in which there is some new methodology of interest to the members

of the profession as a group. This policy, combined with financial limitations, has tended to reduce the total number of papers published over the years. The *Annals* has published only 13 articles about the United States as a whole since 1920.

In the selection of papers for the *Annals*, apparently no thought has been given to the geographical distribution of topics in the United States, for the map indicates certain areas of concentration and some areas of neglect. The preoccupation of the Wisconsin geographers with conditions in the driftless area of that state is noticeable, and the studies of the Chicago and Wisconsin geographers have produced a concentration of interest around the southern end of Lake Michigan. Areas of general neglect or lack of attention include New England, the Southeast, and the



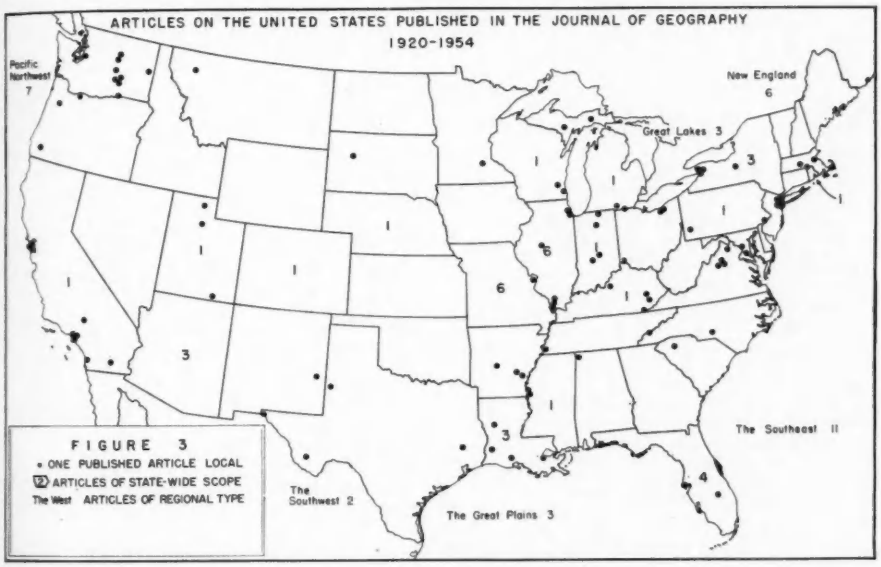
Pacific Northwest. All told, exactly half of the states of the Union have had no article about any feature of their geography published in the *Annals* since 1920, although fourteen articles about states as a whole have been published.

It is probable that uneven geographic distribution of published articles stems from the fact that the editorship of the *Annals* has changed with some frequency, allowing the content of the publication to vary with the interests of different editors. In contrast, the editorship of the *Geographical Review* changes less often, providing a greater degree of stability in editorial practice.

THE JOURNAL OF GEOGRAPHY

The third of the periodicals, the *Journal of Geography*, is a professional publication whose content is directed at a particular reading clientele, primarily those

engaged in teaching the subject in elementary and secondary schools. Its articles, therefore, are written and selected with the grade teacher's needs in mind, though many of the articles are written by geographers in American colleges and universities. The map of articles dealing with the United States (Fig. 3) indicates a tendency to publish material that can be pinpointed in location, and a smaller number of articles dealing with the states or with regions, though thirty-six titles cover the entire nation in scope of subject-matter. A possible explanation of this tendency may be that subjects of state-wide or regional scope are too complex to be used successfully in teaching grade-school units.

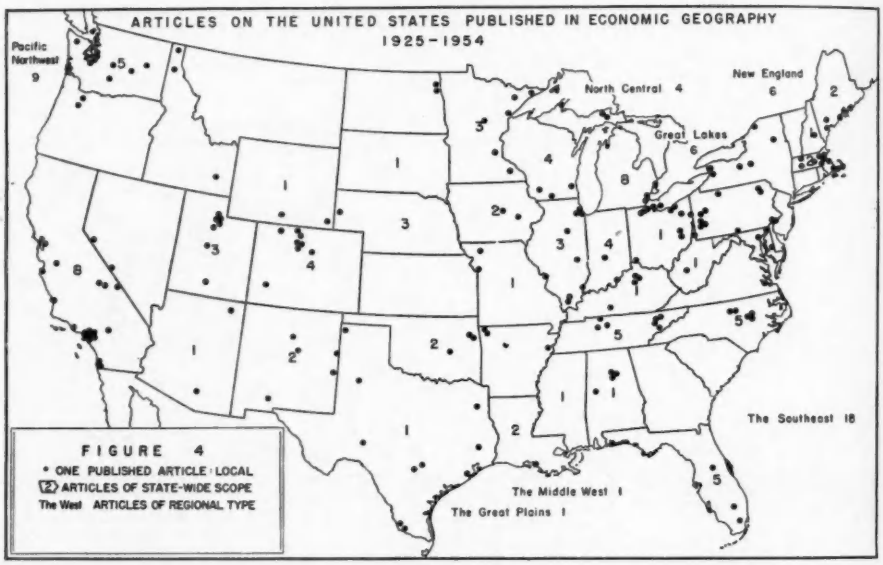

ARTICLES ON THE UNITED STATES PUBLISHED IN THE JOURNAL OF GEOGRAPHY
1920-1954
Pacific Northwest 7
New England 6
Great Lakes 3
The Southeast 11
The Southwest 2
The Great Plains 3
FIGURE 3
• ONE PUBLISHED ARTICLE LOCAL
(2) ARTICLES OF STATE-WIDE SCOPE
The West ARTICLES OF REGIONAL TYPE

The distributional data appearing on Figure 3 indicate a pronounced emphasis upon the eastern United States, particularly within the bounds of the American manufacturing belt. Areas of relative neglect include the Northeast, the Southeast, the Mid-Western States west of the Mississippi River, and the Mountain States. The Pacific Northwest and California are well represented, and apparently the Columbia Basin and its geographic problems have been well covered.

ECONOMIC GEOGRAPHY

The map showing locations of United States articles published in *Economic Geography* (Fig. 4) covers the period from 1925 through 1954. Many of the topics in this professional publication deal with aspects of urban geography, which is apparent in the clusters of studies in western Pennsylvania, northwestern Ohio, around Chicago, in eastern Massachusetts, near Salt Lake City, the Puget Sound

area, and in southern California. Though the distribution of localities seems widespread at first glance, nine states have been entirely neglected or omitted in the selection of papers published in *Economic Geography*: Vermont, Rhode Island, Connecticut, New Jersey, Delaware, South Carolina, Georgia, Kansas, and Montana. The Southeast as a region has attracted many writers, as eighteen articles on this regional topic would indicate. Fifty-three titles dealing with the entire United States have appeared in *Economic Geography,* but the main emphasis has been placed on the individual states (eighty-three articles) and upon areas or units smaller than the states (183 articles). A probable explanation of the trend may



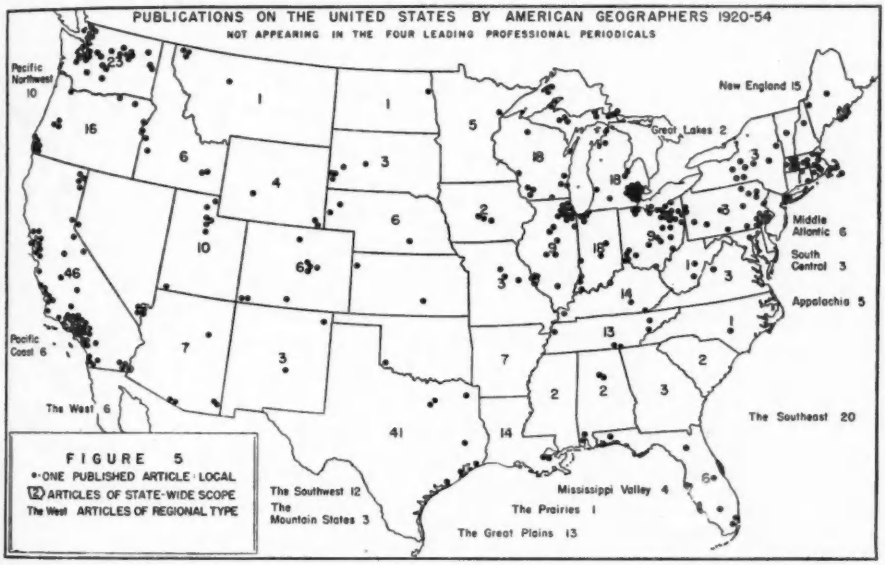
lie in the fact that economic data in this country are usually available by states rather than by regions, since regional studies are only forty-five in number.

OTHER PUBLICATIONS

A large body of geographic material prepared by professional geographers has been published outside the four leading periodicals. A survey of this material has produced the fifth map in the series (Fig. 5), involving a study of twenty-eight other publications, of which nine were quarterlies of state scientific associations; five were regional geographic publications; five were foreign publications; one was a university research series; and others included the *Professional Geographer, Landscape, Focus, Bulletin of the Geographical Society of Philadelphia, Education, The Scientific Monthly,* and the *Journal of Geology.* Figure 5 is particularly significant to members of the geographical profession because it represents the extent to which much of our research is acceptable for publication outside our own field,

and the extent of our professional influence in other disciplines. The more articles we publish in such a widely-read periodical as *Scientific Monthly*, the more the general public becomes familiar with the literature of geography. The number of articles (a total of 352 localities, 320 states, 106 regions, and 74 on the whole country) mapped on Figure 5 represents a healthy excursion on the part of professional geographers into fields outside their own, at least as far as publication is concerned.

Concentration of interests accounts for the nodes appearing on Figure 5. The school of geography at Clark University explains the large group of studies in


PUBLICATIONS ON THE UNITED STATES BY AMERICAN GEOGRAPHERS 1920-54
NOT APPEARING IN THE FOUR LEADING PROFESSIONAL PERIODICALS
Pacific Northwest 10
New England 15
Great Lakes 2
Middle Atlantic 6
South Central 3
Appalachia 5
Pacific Coast 6
The West 6
The Southeast 20
The Southwest 12
The Mountain States 3
Mississippi Valley 4
The Prairies 1
The Great Plains 13
FIGURE 5
• ONE PUBLISHED ARTICLE · LOCAL
(2) ARTICLES OF STATE-WIDE SCOPE
The West ARTICLES OF REGIONAL TYPE

Massachusetts. The Geographical Society of Philadelphia and its *Bulletin* evidently sponsored research in southeastern Pennsylvania. The centers of geographic activity at Wayne University and at the University of Michigan account for the interest in southeastern Michigan. Chicago's contributions are numerous, while the large numbers of articles dealing with California and Washington geography represent twenty years of publication of the *Yearbook of the Association of Pacific Coast Geographers*.

In a few cases the specific interests of individuals appear on Figure 5. For example, the publications of Richard J. Russell in the University of California series are represented by a cluster of dots in northeastern California. In southwestern Oregon, the articles by Willis Merriam dealing with the Rogue River country stand out plainly. Many articles mapped for Texas reflect much of the material published in the *Texas Geographic Magazine*.

Few neglected areas appear on this map. New Jersey and Delaware are the only states entirely unrepresented by articles, either statewide or local in scope. Some of the southeastern states, as well as Oklahoma and Kansas, would seem worthy of more intensive geographical investigation than they have received.

DOCTORAL DISSERTATIONS

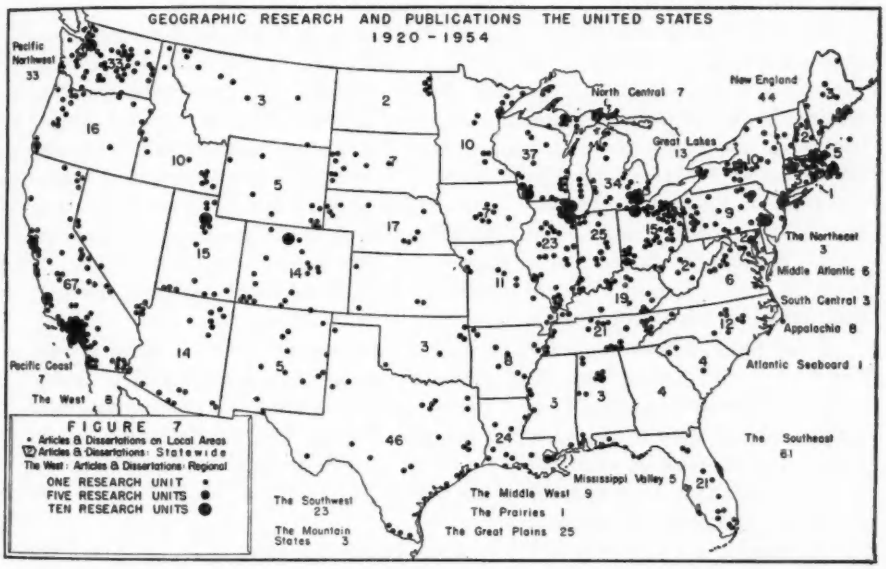
The map of the distribution of doctoral dissertations (Fig. 6) dealing with the United States is particularly interesting, since it represents most of the original contributions to American geography that have come from researches connected

with the doctoral degrees conferred in this country. The titles of theses mapped here were taken from the list compiled by fourteen graduate students at the University of Washington in the Department of Geography during 1953 and 1954, and from lists published in the *Professional Geographer*. The compilation provided the titles of doctoral dissertations from twenty-three universities, and to these were added thesis titles accepted at George Peabody College for Teachers. Unlike the preceding maps, Figure 6 includes much unpublished material. Sixteen titles were nation-wide in scope.

A pronounced imbalance appears in the distribution of topics, since the greatest number of subjects deals with places, states, or regions located east of the Mississippi River. It is probable that this unequal distribution represents the fact that our larger and older departments of geography are mainly associated with eastern

universities. It also suggests that the selection of topics for investigation by candidates for the doctorate has been tailored to meet the needs of those who were unable to spend money for travel and field work in distant locations. This would seem to be a factor in Massachusetts and Illinois.

Certain special interests appear plainly on this map. Students at the University of Michigan have used the Upper Peninsula for many years as a geographic laboratory, and there is concentration of interest in the Wisconsin driftless area. One inescapable question arises: Why has there been such apparent neglect of geography of the Middle West? The relatively small numbers of thesis topics developed in



that part of the nation seem striking. Possibly the situation will be corrected a few years hence when young departments of geography at Kansas and Texas universities come into full production. One other comment on Figure 6 seems in order: it shows more than three times as many thesis topics dealing with states than with regions—in spite of a considerable lip service to regional geography.

Neglected areas on this map include the entire state of West Virginia, within which some of the most interesting industrial developments have occurred within the last decade, but apparently no topic there suggested itself as worthy of original investigation by candidates for the doctoral degree or by their departmental chairmen. Delaware once again has been neglected and there is a wide-open space around the city of New York. Evidently the geographic aspects of that metropolis

have been of too great magnitude for doctoral studies, though the city is well represented in the four professional publications previously discussed.

THE COMPOSITE

Combining all the information conveyed in Figures 1 through 6, the composite map (Fig. 7) includes the geographical localities, states, and regions with which most American geographic research and publication have been concerned for over a quarter of a century. In all, 267 published items (not appearing on the accompanying maps) have covered phases of the geography of the United States as a whole, and more than twice the numbers of articles (573) deal with states rather than with regions (260).

There is conspicuous maldistribution of interests, and certain areas have been over-researched in relation to others. The map (Fig. 7) indicates an enormous geographical curiosity about Cape Cod, the Boston and Worcester areas, the Connecticut Valley of western Massachusetts, northeastern Ohio, the upper Michigan peninsula, southwestern Wisconsin, eastern Tennessee, north-central Colorado, the Columbia Basin, and the Sierra Nevada. Cities of greatest attraction in geographical studies seem to be New York, Philadelphia, Toledo, Detroit, Cleveland, Buffalo, Cincinnati, Chicago, Salt Lake City, Seattle, San Francisco, and Los Angeles. Pittsburgh, the cities of up-state New York, the Florida resorts, New Orleans, St. Louis, Kansas City and Omaha, and the Texas cities have had relatively little attention from geographers.

Some rural sections seem to have received geographic attention out of proportion to their significance; these include southwestern Oregon, interior New Hampshire, southwestern Colorado, and southeastern Wyoming. A concentration of articles dealing with rural aspects of San Luis Obispo County, California, clearly reflects the interests of John Wesley Coulter as well as those of this author. It seems strange that some sections of northern California have been given so little attention by professional geographers.

Geographic voids on Figure 7 include, as before, the state of Delaware and the Delmarva Peninsula; the mountains of western Virginia and North Carolina; the west coast of Florida; the state of Georgia; southern Missouri, western and northern Minnesota, all of North Dakota except the Red River Valley; eastern South Dakota, most of Kansas, Oklahoma, southwestern Montana and the rugged parts of Idaho; almost all of Nevada; the Mohave desert and northwestern California. Certainly within these blank spots of geographical research and publication there should be topics worthy of investigation. A few that come to mind would include studies of the changing land occupance in Amarillo; tourism in the Great Smokies; the Okefenokee Swamp; the Missouri Ozarks; some Indian reservations other than the Hopi and Navaho; the ranch as a settlement unit of central Nevada; the Humboldt Bay region of northern California; the geography of navigation on the Columbia River, and the regional aspects of the Owyhee country.

CONCLUSION

From a study of the seven maps presented herein, it is apparent that members of the geographical profession have been active in their investigations of the geography of their own country, but it is equally evident that there are many wide gaps in the pattern, representing numerous "deserts" in the professional geographic literature of the United States. It seems unlikely that there is an impending shortage of topics suitable for geographic study.

EXTENDED USES OF POLYCONIC PROJECTION TABLES

JOHN LEIGHLY

University of California, Berkeley

THOUGH devised as a projection for topographic sheets, the American polyconic projection was long used, both within and without the United States Coast and Geodetic Survey, the agency in which it was invented, for maps drawn on smaller scales. The tables published by the Survey[1] facilitate such use by giving rectangular coordinates for the projection out to 30 degrees of longitude from the mid-meridian. Extension of the projection to even half that range in longitude is to be deplored; and it is to the great credit of the Survey that it has actively contributed to the obsolescence of the parts of the polyconic tables that apply to the greater distances from the mid-meridian, by fostering use of the Lambert and Albers conic projections with two standard parallels.

The parts of the polyconic tables that refer to the larger departures (the term "departure" will be used here to designate longitude reckoned from the mid-meridian) retain, however, a permanent value. By providing an already computed conic development of parallels, at intervals of one degree of latitude, out to 30 degrees of departure they lend themselves to the construction of various projections of the conic class. It is the purpose of the present article to show how the tables can be used for constructing two conic projections for maps of intermediate scale, which are more useful in such maps than the polyconic projection and can be drawn with less labor than any other projection likely to be used for them. There are undoubtedly other applications of the tables that remain to be devised.

THE SIMPLE CONIC PROJECTION WITH ONE STANDARD PARALLEL

The frequent use made in atlases of the simple conic projection with one standard parallel is evidence enough of the continuing usefulness of this venerable projection. It is particularly useful when the scale of the map to be drawn is small enough to permit one to draw the parallels with a beam compass; if rectangular coordinates have to be computed, it is usually worth while to perform the additional computation required for the construction of one of the conic projections with two standard parallels. My concern here is with scales at which that most satisfactory drafting instrument, the beam compass, can be used. What these scales are can be judged from a consideration of the lengths of radii of developed parallels in conic projections. It is scarcely practicable to use the beam compass for drawing arcs having radii longer than about 150 centimeters. Table I shows the scale, to the nearest thousandth, of parallels at intervals of 10 degrees from 20 to 80 degrees of

[1] *Tables for a Polyconic Projection of Maps Based upon Clarke's Reference Spheroid of 1866,* U. S. Coast and Geodetic Survey, Special Publication No. 5, various editions and dates.

latitude, if developed by the procedure commonly used for the standard parallel in the simple conic projection, and with radius 150 centimeters. These are thus approximately the largest scales at which the parallels can be drawn with the beam compass. In middle latitudes they fall at the lower limit of the range of scales of regional maps; in higher latitudes well within that range. The radii of parallels in low latitudes, on almost any scale likely to be used in regional maps, are usually too long to allow use of the beam compass.

TABLE I

SCALE ON DEVELOPED PARALLELS WITH RADIUS 150 CENTIMETERS

Latitude, degrees	20	30	40	50	60	70	80
Scale, 1:1000 times	11,687	7,371	5,075	3,575	2,461	1,552	752

In order to draw parallels in the simple conic projection with the beam compass, the length of the radius of at least the standard parallel must be known. Lengths of radii of parallels in simple conic development have been published for the sphere and for the Bessel spheroid;[2] but although rectangular coordinates of parallels based on the Clarke spheroid of 1866 have been published many times in the United States, the radii from which these coordinates were computed seem never to have been published. Table II gives, from my computation, the lengths of these radii in their natural scale, to one decimal of kilometers, at intervals of one degree from 15 to 80 degrees of latitude, and for the tropics and polar circles. These lengths are the slant heights of cones tangent to the spheroid at the respective latitudes, from the parallel of tangency to the apexes of the cones. They are computed from the formula

$$l = \rho_n \cot \varphi,$$

where l is the length of the radius of the developed parallel and ρ_n the radius of the section of the spheroid normal to the meridian at latitude φ.[3]

[2] For the sphere, at intervals of one degree of latitude and in units of one equatorial degree: Thomas Craig, *A Treatise on Projections* (Washington, 1882), p. 230. For the Bessel spheroid at intervals of one degree of latitude: in meters, U. S. Navy Dept., Bureau of Navigation, *Projection Tables for the Use of the United States Navy. . . .* (Washington, 1869), pp. 232–233; and in kilometers, Karl Zöppritz, revised by Alois Bludau, *Leitfaden der Kartenentwurfslehre, I: Die Projektionslehre* (ed. 3; Leipzig and Berlin, 1912), p. 259. At intermediate map scales and for middle latitudes the differences between radii derived from the Bessel and the Clarke spheroids lie at or within the limit of error of plotting; the differences between the radii derived from a sphere of mean radius and from the spheroid are measurable.

[3] The length of ρ_n in meters was obtained by changing the seven-place logarithms of ρ_n in feet given in R. S. Woodward, "Smithsonian Geographical Tables," *Smithsonian Miscellaneous Collection*, 854 (ed. 3, 1929), pp. 57–65, to logarithms of meters by the conversion proposed by C. H. Birdseye, *Formulas and Tables for the Construction of Polyconic Projections*, U. S. Geological Survey Bulletin 809 (1929), p. 8. The lengths in meters, to seven significant digits, were then taken out of logarithms and multiplied by cot φ, taken to seven decimal places, to give l in meters. The decimal point was moved and the last two digits discarded to obtain the numbers in Table II.

The radii tabulated in Table II, in conjunction with the polyconic projection tables, may be used in the following manner for constructing a simple conic projection with one standard parallel:

1. Select the standard parallel, take its radius from Table II, and reduce it to scale.

2. Draw the mid-meridian, and mark a point on it as the intersection of the standard parallel with it.

TABLE II

RADII OF PARALLELS IN CONIC DEVELOPMENT, BASED ON THE CLARKE SPHEROID OF 1866 (NATURAL SCALE)

Latitude, degrees	Radius, km.	Latitude, degrees	Radius, km.	Latitude, degrees	Radius. km.	Latitude, degrees	Radius, km.
15	23,809.2	31	10,624.7	48	5,753.7	65	2,982.5
16	22,249.2	32	10,217.0	49	5,555.2	66	2,347.8
17	20,868.2	33	9,831.5	50	5,362.6	66°33′	2,774.6
18	19,636.4	34	9,466.1	51	5,175.6	67	2,715.2
19	18,530.3	35	9,119.2	52	4,993.7	68	2,584.5
20	17,530.9	36	8,789.1	53	4,816.7	69	2,455.6
21	16,623.0	37	8,474.6	54	4,644.3	70	2,328.4
22	15,794.1	38	8,174.2	55	4,476.2	71	2,202.9
23	15,033.9	39	7,887.0	56	4,312.2	72	2,078.8
23°27′	14,711.8	40	7,611.9	57	4,152.0	73	1,956.1
24	14,333.7	41	7,348.0	58	3,995.3	74	1,834.7
25	13,686.4	42	7,094.5	59	3,842.0	75	1,714.5
26	13,085.8	43	6,850.6	60	3,691.9	76	1,595.4
27	12,526.7	44	6,615.6	61	3,544.7	77	1,477.3
28	12,004.6	45	6,389.0	62	3,400.3	78	1,360.1
29	11,515.8	46	6,170.2	63	3,258.6	79	1,243.8
30	11,056.7	47	5,958.6	64	3,119.4	80	1,128.4

3. Prolong the mid-meridian poleward to a length sufficient to include the common center of the arcs that will represent the parallels. Mark on the prolongation of the mid-meridian the common center of these arcs, at the length of the radius of the standard parallel from the point of intersection of this parallel with the mid-meridian.

4. Take from the polyconic projection tables lengths of arcs of the meridian at the interval of latitude desired for the parallels, reduce them to scale, and measure them upward and downward on the mid-meridian from the standard parallel to determine the points at which the several parallels cross the mid-meridian.

5. With the pole of the beam compass at the common center of the parallels, draw all the parallels through the points marked on the mid-meridian.

6. To obtain the meridians, draw in pencil an axis of abscissas through the point of intersection of the standard parallel and the mid-meridian, tangent to the parallel. Lay out on this axis, to right and left of the mid-meridian and at the desired interval of longitude between meridians, the X-coordinates of the standard parallel taken from the polyconic tables and reduced to scale. Perpendiculars erected from the points thus found on the X-axis of the standard

parallel intersect the parallel at the points at which the respective meridians cross it. The parallel being already drawn, the Y-coordinates are not needed. Draw the meridians as straight lines from the center of the arcs that represent the parallels through the points marked on the standard parallel.

The only computation required, most of which can be done with the slide-rule, is the reduction of a few lengths to scale.

Distortion in the Simple Conic Projection. In the simple conic projection with one standard parallel the scale is true on the standard parallel and all meridians, but on the other parallels it increases northward and southward from the standard parallel. The scale on any parallel is easy to formulate for the sphere, but computing it requires some labor. If the radius of the sphere reduced to the scale of the map is denoted by R, then the radius l_s of the arc that represents the standard parallel, in latitude φ_s, is $R \cot \varphi_s$. The radius l of any other parallel, in latitude φ, is equal to l_s increased or diminished by the length of the arc of the meridian between latitudes φ_s and φ. The length of this arc is

$$2\pi R(\varphi - \varphi_s)/360,$$

if latitudes are expressed in degrees. The numerical value of $2\pi/360$, the equivalent in radians of one degree, is 0.017453. The radius of the arc representing the parallel of latitude φ is, then,

$$l = R \cot \varphi_s - 0.017453\, R(\varphi - \varphi_s) = R[cot\, \varphi_s - 0.017453(\varphi - \varphi_s)].$$

The length of the parallel of latitude φ on the map, within the sector determined by the latitude of the developed standard parallel, is

$$2\pi R[\cot \varphi_s - 0.017453(\varphi - \varphi_s)] \sin \varphi_s.$$

The length of the parallel on the sphere is $2\pi R \cos \varphi$. Then k, the ratio of the scale along the parallel to the true scale along the standard parallel and the meridians (the "relative" scale on the parallel), is given by

$$\begin{aligned} k &= \{2\pi R[\cot \varphi_s - 0.017453(\varphi - \varphi_s)] \sin \varphi_s\}/2\pi R \cos \varphi \\ &= [\cos \varphi_s - 0.017453 \sin \varphi_s(\varphi - \varphi_s)]/\cos \varphi, \end{aligned} \tag{1}$$

latitudes being expressed in degrees.

In Figure 1 values of k up to 1.06—that is, to an exaggeration of scale of 6 percent—are plotted for the range of latitude represented in Table 2. An exaggeration of scale as large as 6 percent would be admissible only in exceptional circumstances. As is evident from the figure, a belt of approximately 15 degrees of latitude can be mapped with an exaggeration of scale less than one percent. That range of latitude is sufficient for many regional maps; and if a scale error of two percent is admitted, the width of the belt can be increased by 7 or 8 degrees. By using the parallel of 38 or 39 degrees as a standard parallel, the entire continental area of the United States can be mapped with a maximum scale error less than 3 percent. That is less than half the scale error along meridians at the eastern and western edges of a map of the United States on the polyconic projection, which

was for a long time the projection customarily used in maps issued by federal agencies, though for this purpose it is now happily superseded. It is of course not my intention to recommend the simple conic projection with one standard parallel for maps of the whole United States.

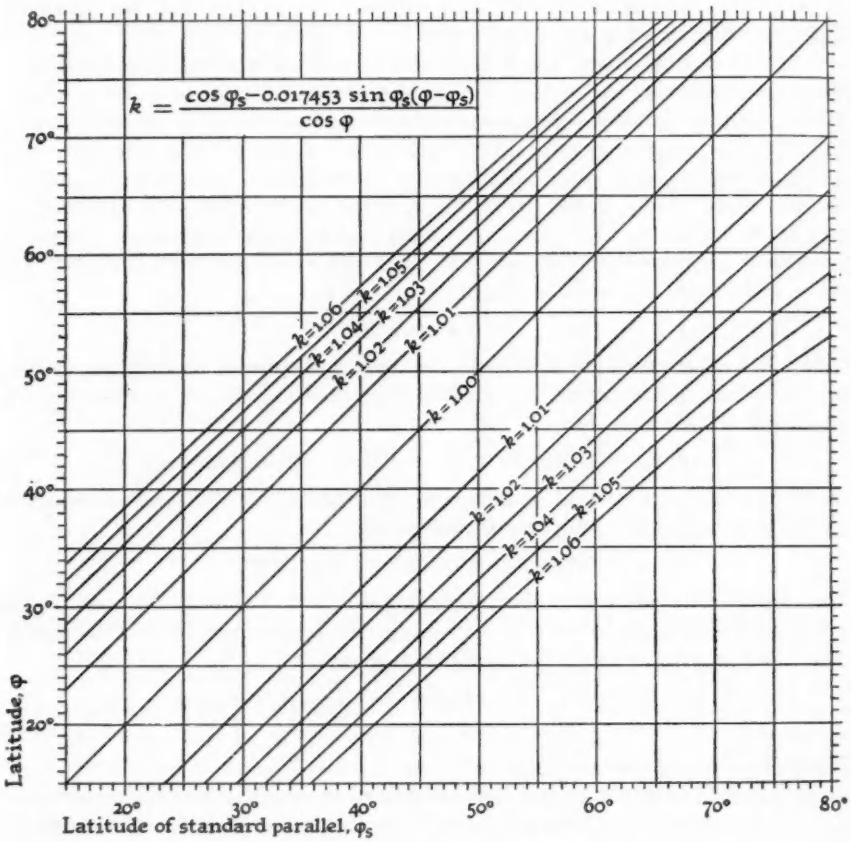


FIG. 1. Exaggeration of scale in the simple conic projection with one standard parallel.

Exaggeration of scale on the parallels is not symmetrical with respect to the standard parallel; hence the standard parallel appropriate to a given zone, especially in higher latitudes, is not always the middle parallel of the zone. The standard parallel appropriate to the zone between any two parallels may be determined from Figure 1 by laying the edge of a piece of paper along the left side of the figure and marking on it the latitudes of the two limiting parallels, together with a fiducial mark at 15 degrees, the bottom of the figure. If the edge of the paper is then moved

parallel to itself to the right across the figure until the two marks show the same scale above and below the diagonal line of true scale, the latitude of the appropriate standard parallel can be read on the scale at the bottom of the figure. The difference between this latitude and the mid-latitude of the zone becomes significant only at higher latitudes. For a map of the Scandinavian Peninsula between latitudes 55 and 72 degrees north, the diagram gives as the appropriate standard parallel, with k slightly in excess of 1.01 at the limiting latitudes, a parallel just north of 64 degrees.

Since the scale is true along the meridians, the exaggeration of area in the simple conic projection with one standard parallel has the same numerical value as k at any latitude. The distortion of angle is wholly the result of the difference in scale along the parallel and the meridian at any point, since these intersect at right angles. The relative scale on the meridian, the axis a in the Tissot indicatrix, is always 1.00, and the axis b is k. The maximum angular distortion, 2ω, can therefore be found from the expression

$$\sin \omega = (k-1)/(k+1).$$

Table III gives the value of 2ω for each of the values of k represented by the curves in Figure 1. Within any admissible exaggeration of scale the angular distortion is not serious.

TABLE III

MAXIMUM ANGULAR DISTORTION IN THE SIMPLE CONIC PROJECTION WITH ONE STANDARD PARALLEL

k	1.01	1.02	1.03	1.04	1.05	1.06
2ω	0°34′	1°10′	1°42′	2°14′	2°48′	3°20′

CONSTRUCTION OF A PROJECTION WITH TWO STANDARD PARALLELS ("CONSTRUCTION B")

It is often necessary to draw regional maps on scales too large to permit use of the beam compass in drawing the parallels. Rectangular coordinates must then be computed and plotted. The polyconic projection can be used for a meridional strip that extends to about 900 kilometers on each side of the mid-meridian with an exaggeration of scale along the meridians that does not exceed one percent.[4] The range of longitude within such a strip varies with latitude in the manner shown to the nearest whole degree of longitude in Table IV. These are appreciable widths, sufficient for most regional maps drawn on scales too large to permit use of the beam compass. But the polyconic projection, when used for areas so large that parallels and meridians cannot be drawn as straight lines, is tedious to construct; many rectangular coordinates must be plotted, and both parallels and meridians drawn with the aid of splines or drafting curves with

[4] Charles H. Deetz and Oscar S. Adams, *Elements of Map Projection with Applications to Map and Chart Construction*, U. S. Coast and Geodetic Survey, Special Publication No. 68 (ed. 5, 1945), p. 62.

large radii of curvature. The following procedure obviates much plotting of coordinates, and in addition the necessity of drawing the meridians as curved lines:

1. Draw and divide the mid-meridian as for the polyconic or simple conic projection.
2. Select two parallels, one in the upper and one in the lower range of latitude to be included in the map, but not at its limits, as standard parallels. A guide for selecting the best standard parallels will be given later in this article.
3. Plot points on these two parallels at the desired interval of longitude between meridians from the coordinates given in the polyconic projection tables, and draw the two parallels through the points plotted.

TABLE IV

WIDTH OF STRIP ON THE POLYCONIC PROJECTION WITHIN WHICH THE SCALE ERROR ALONG MERIDIANS IS LESS THAN ONE PERCENT

Latitude, degrees	20	30	40	50	60	70	80
Width, degrees of longitude	17	19	21	25	32	47	93

4. Draw the meridians as straight lines through the appropriate pairs of plotted points on the two parallels, extending them as far north and south of the standard parallels as is necessary.
5. Divide the segments of the meridians between the standard parallels into as many equal parts as are needed for drawing the other parallels desired, and draw these other parallels with the spline or curve through the points of division of the meridians. Since the divisions of any one meridian are equal in length, as many of these lengths as are needed can be laid out north and south beyond the standard parallels, to provide points through which parallels beyond the standard parallels can be drawn. Dividing the meridians into equal parts is much less laborious than plotting points from rectangular coordinates.

I used a projection thus constructed for a map of the East Baltic region published in 1939.[5] This map includes slightly more than 5 degrees of latitude and 8 degrees of longitude. The parallels of 56 and 60 degrees north latitude were plotted from the coordinates given in the polyconic projection tables, and the remainder of the projection built up in the manner just described, with parallels and meridians at intervals of one degree of latitude and longitude.

The conic projection definable in simple geometric terms that most closely resembles the construction described (which will hereinafter be called "construction B") is J. N. de l'Isle's projection, the simple conic projection with two standard parallels. Computation on a scale of 1:2,000,000 of the rectangular coordinates for the parallels of 56 and 60 degrees of latitude on de l'Isle's projection shows that within a range of 4°30′ of longitude on each side of the mid-meridian these coordinates differ at most by 0.01 centimeter from the coordinates of the same

[5] "The Towns of Medieval Livonia," University of California Publications in Geography, Vol. 6, No. 7 (1939), Fig. 3, opposite p. 249.

parallels in the polyconic projection on the same scale; the difference is thus within the error of plotting. As one proceeds outward from the mid-meridian, differences appear first in the Y-coordinates. The parallels in the de l'Isle projection are concentric, struck from a center corresponding to the center of a developed parallel approximately halfway between the two standard parallels; in the map of the Baltic region, the parallel of 57°59′. The parallels in the polyconic projection are developed individually; the standard parallel in the higher latitude has a shorter radius, and that in the lower latitude a longer one, than their counterparts in the de l'Isle projection. The scale along the meridians in construction B increases outward from the mid-meridian as the parallels diverge. The tolerable limits in longitude of construction B are set by the same considerations as are applicable to the polyconic projection. The meridians being drawn as straight rather than curved lines, the scale along them is exaggerated slightly less than in the polyconic projection, and between the standard parallels the scale along the parallels is slightly reduced.

Scale on the Parallels. Construction B cannot, like the polyconic projection, be used for a meridional strip of unlimited extent. Its admissible limits in a meridional direction can be estimated from consideration of the change with latitude of the scale along the parallels in de l'Isle's projection.

The radii of parallels in the de l'Isle projection, using the sphere, are found thus: Let the latitudes of the two standard parallels be denoted by φ_1 and φ_2, $\varphi_2 > \varphi_1$; and the latitude of the mid-parallel, halfway between them, by φ_c; φ_c is thus $(\varphi_1 - \varphi_2)/2$. Let the radius of the mid-parallel as drawn on the map be designated ρ_c, and the radii of the standard parallels, respectively, ρ_1 and ρ_2. Since the scale along the meridians is true, ρ_1 is equal to ρ_c increased by the length of the arc of the meridian, on the scale of the map, corresponding to the difference in latitude $\varphi_c - \varphi_1$, and ρ_2 is equal to ρ_c diminished by the length of the arc corresponding to the difference $\varphi_2 - \varphi_c$. These two arcs are equal, each being half of the arc of the meridian between the standard parallels. The arc of the meridian between these is

$$2\pi R(\varphi_2 - \varphi_1)/360, \text{ or } 0.017453\, R(\varphi_2 - \varphi_1),$$

R being the radius of the sphere reduced to scale. The arcs between the mid-parallel and each of the standard parallels have half this length, or

$$0.0087266\, R(\varphi_2 - \varphi_1).$$

Hence

$$\rho_1 = \rho_c + 0.0087266\, R(\varphi_2 - \varphi_1), \tag{2a}$$

$$\rho_2 = \rho_c - 0.0087266\, R(\varphi_2 - \varphi_1). \tag{2b}$$

On the sphere the parallel of latitude φ_1 has the length $2\pi R \cos \varphi_1$, and the parallel of latitude φ_2 the length $2\pi R \cos \varphi_2$. On the map the lengths of the two parallels out to the edge of the sector formed by the developed cone are

$$2\pi n[\rho_c + 0.0087266\, R(\varphi_2 - \varphi_1)] \text{ and}$$
$$2\pi n[\rho_c - 0.0087266\, R(\varphi_2 - \varphi_1)],$$

where n is the "constant of the cone," the fraction of 360° occupied by its developed surface. The value of n remains to be found.

If the lengths of the two standard parallels on the map are set equal to their lengths on the sphere reduced to scale, two simultaneous equations are obtained, which may be solved to find n and ρ_c:

$$2\pi n[\rho_c + 0.0087266\,R(\varphi_2 - \varphi_1)] = 2\pi R\cos\varphi_1,$$
$$2\pi n[\rho_c - 0.0087266\,R(\varphi_2 - \varphi_1)] = 2\pi R\cos\varphi_2,$$

whence

$$n\rho_c + 0.0087266\,nR(\varphi_2 - \varphi_1) = R\cos\varphi_1,$$
$$n\rho_c - 0.0087266\,nR(\varphi_2 - \varphi_1) = R\cos\varphi_2.$$

From these one obtains

$$n = (\cos\varphi_1 - \cos\varphi_2)/[0.017453(\varphi_2 - \varphi_1)], \tag{3}$$

$$\rho_c = [R(\cos\varphi_1 + \cos\varphi_2)]/2n. \tag{4}$$

The radius ρ of any parallel of latitude φ is obtained by adding algebraically to ρ_c the length of the arc of the meridian between the mid-parallel and φ, reduced to scale. This length is $0.017453(\varphi_c - \varphi)$, latitudes in degrees; and

$$\rho = [R(\cos\varphi_1 + \cos\varphi_2)/2n] + 0.017453R(\varphi_c - \varphi).$$

The length of the developed parallel of latitude is $2\pi n\rho$. Its length on the sphere is $2\pi R\cos\varphi$. The relative scale, k, along the developed parallel is the ratio of these lengths:

$$k = 2\pi n\rho/2\pi R\cos\varphi = n\rho/R\cos\varphi.$$

When the values of n and ρ are introduced from (3) and (4), and φ_c is replaced by its equivalent $(\varphi_1 + \varphi_2)/2$, this expression becomes

$$k = [\cos\varphi_1(\varphi_2 - \varphi) - \cos\varphi_2(\varphi_1 - \varphi)]/\cos\varphi(\varphi_2 - \varphi_1). \tag{5}$$

Because of the large number of possible combinations of standard parallels, no simple diagram such as Figure 1 can be drawn from which the scale along the parallels could be read. Such diagrams as the two included in Figure 2 can be constructed, however, for given tolerances of scale error. The purpose of using two standard parallels instead of one being to reduce the maximum error, I have assumed that an error in excess of two percent would scarcely be tolerated in such maps as are contemplated here.

The diagrams in Figure 2 show, in coordinates latitude of mid-parallel and latitude of any parallel, the range of latitude within which the scale error along the parallels remains, in A, within one percent, and in B within two percent. The other lines show the latitudes of the standard parallels, on which the scale is true ($k = 1.00$), and the latitudes in which it is reduced by the same amount as it is exaggerated along the outermost lines in the two diagrams ($k = 0.99$ or 0.98). The belts of latitude beyond the standard parallels within the stated exaggerations of scale are much narrower than the belts between the standard parallels and the

parallels with maximum reduction of scale. Their widths vary with latitude, and the belts are not symmetrical with respect to the parallel with maximum reduction of scale.

Figure 2 does not give so much information, nor in so convenient a form, as Figure 1 does concerning the simple conic projection with one standard parallel, but if it is entered with a specific region in mind it answers some questions concern-

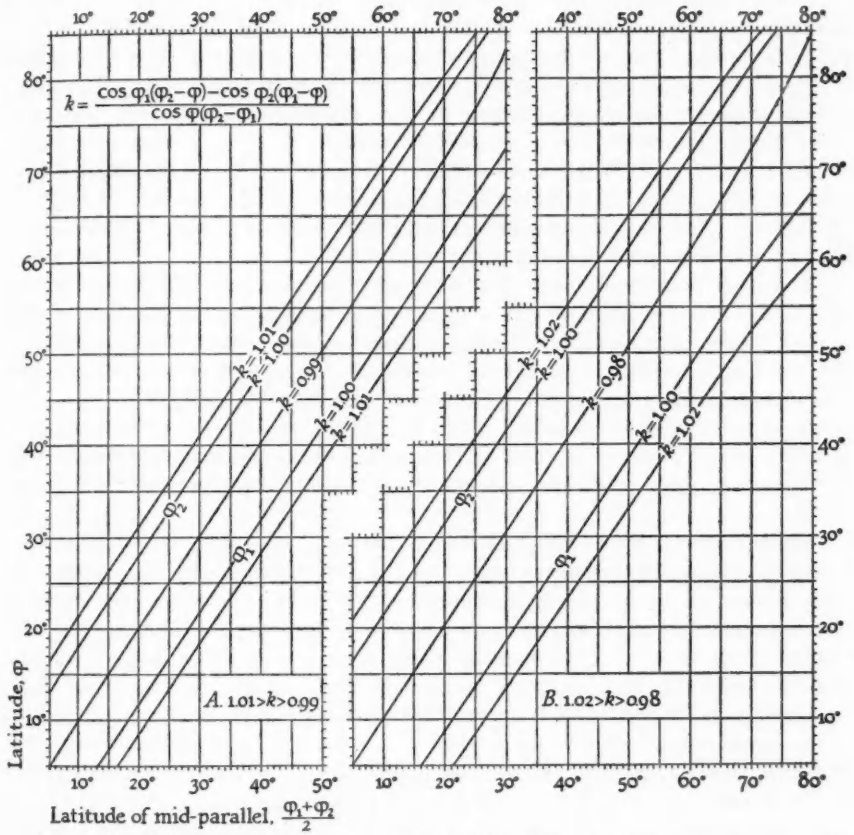


FIG. 2. Latitudes of certain exaggerations of scale along parallels in the simple conic projection with two standard parallels (de l'Isle's projection).

ing the distortion of scale along the parallels if the region were mapped in the de l'Isle projection. Thus, to recall the whole continental United States, the zone between latitudes 25 and 50 degrees does not quite fit beween the curves of one percent exaggeration in Figure 2, *A*, but it extends only slightly beyond them. If construction B were used, the exaggeration of scale along the meridians at the

eastern and western extremities of the map, rather than the exaggeration along the parallels, would exclude consideration of the construction for so large an area.

A map of Alaska, with limiting parallels 50 and 72 degrees north latitude, falls within the range shown in Figure 2, *A*, with a distortion of scale along the parallels not exceeding one percent, if standard parallels are taken at about 54 and 70 degrees. Again, according to Table IV, only about half of the extreme width of Alaska, from the southern Panhandle to the remote Aleutians, would lie within the strip in which, in the polyconic projection, the exaggeration of scale along the meridians is less than one percent. The whole range of latitude of Greenland, from 59 to 84 degrees north latitude, just escapes inclusion within the range in which the exaggeration of scale does not exceed one percent. A little computation shows that, using the difference in latitude between the standard parallels for a maximum scale error of ± 0.01, namely 16°12′, and a mid-parallel in latitude 72 degrees, the relative scale passes 1.010 just beyond latitude 82 degrees, is 1.017 at 83 degrees, and 1.028 at 84 degrees. The scale changes rapidly with latitude in these high latitudes, with the rapidly changing value of the cosine of latitude.

A map of Scandinavia extending from about latitude 54 to 73 degrees north falls well within the limits of an exaggeration of scale along the parallels of one percent. According to Table IV, the polyconic projection has a scale error along the meridians less than one percent out to about 15 degrees of departure in the lower latitudes included. Construction B, with meridians drawn as straight lines through points of division of the standard parallels constructed from the polyconic tables at about 58 and 71 degrees, would yield a map of the Scandinavian Peninsula and the Baltic region in which the scale error would everywhere be within the range ± 0.01.

While Figure 2 gives a general notion of the range of latitude within which the scale does not exceed the limits given when a map is drawn on the de l'Isle projection, it does not permit a ready determination of the scale error in a map included between any two given parallels. By equation (5), k may be computed for any latitude if the latitudes of the standard parallels are known. But in the construction of a projection the area to be included is defined by the latitudes of its limits in a meridional direction, not by standard parallels, which have to be selected. What is desired, in constructing a map of a given area, are the latitudes of the standard parallels that will give the least scale error on the limiting parallels at the northern and southern extremities of the region to be mapped. This scale error is given by equation (5) only when, the standard parallels being given, the latitudes of the limiting parallels, which will be called φ_0 and φ_3, $\varphi_3 > \varphi_0$, are introduced instead of φ. A general solution of the problem of the scale on the limiting parallels and the appropriate standard parallels can be achieved only by computing a sufficient number of combinations of standard parallels and putting the results into a table or a diagram. Figure 3, *A*, is such a diagram. Its coordinates are φ_0 and φ_3, the latitudes of the limiting parallels. Three sets of curves are drawn in these coordinates: the latitudes of the standard parallels, φ_1 and φ_2, that give the least

exaggeration of scale at the limiting parallels, at latitudes φ_0 and φ_3; and the relative scale, k_e, on these limiting parallels when the appropriate standard parallels are used. With each of these values of k_e, the relative scale k at some latitude between the standard parallels has a minimum value $(2.000 - k_e)$.

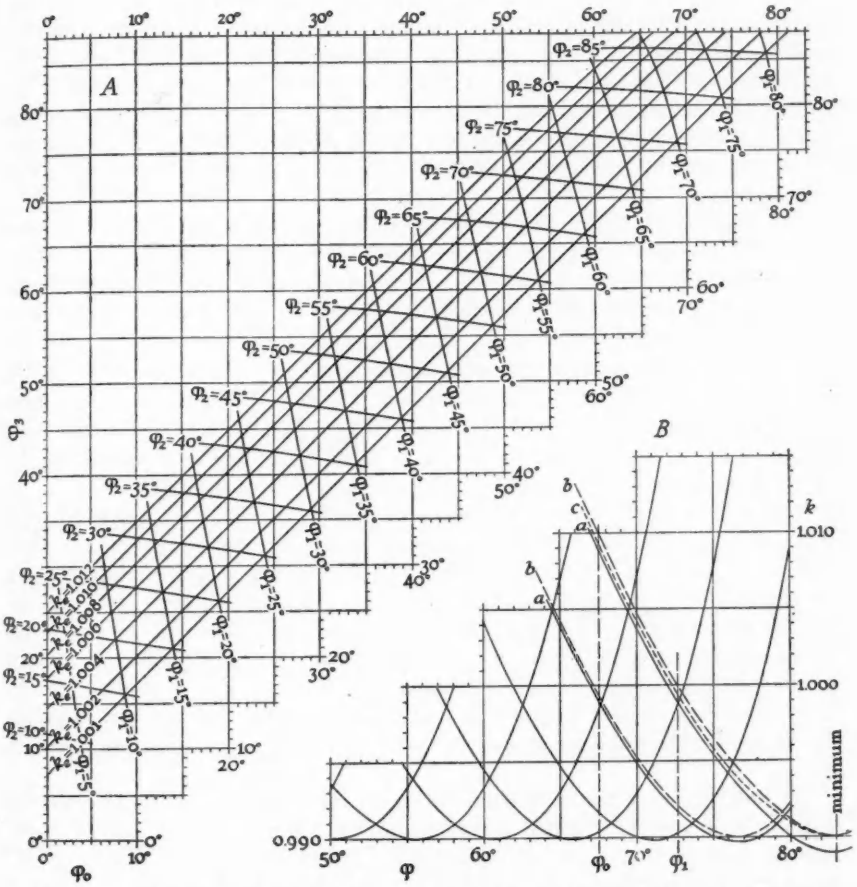


FIG. 3. *A*, relative scales on limiting parallels, and standard parallels that give these relative scales, plotted as functions of latitudes of the limiting parallels; de l'Isle's projection. *B*, copy of part of the working diagram used in obtaining the numerical material plotted in *A*.

To return to the regions mentioned in an earlier paragraph: Alaska, between latitudes $\varphi_0 = 50$ degrees and $\varphi_3 = 72$ degrees north, may be mapped in the de l'Isle projection, standard parallels 54 degrees and 69 degrees north, with a scale error along the limiting parallels of about 0.009. In a map of Greenland, $\varphi_0 = 59$ degrees,

$\varphi_2 = 84$ degrees, the scale error on the limiting parallels exceeds 0.012. A slight extrapolation indicates that the error is about 0.014, with standard parallels 64 and 82 degrees north. As for Scandinavia, with limiting parallels 54 and 73 degrees north, a map with standard parallels at 57 and 71 degrees has an exaggeration of scale less than 0.08 at top and bottom. The sectional maps of the United States published by the National Geographic Society could be drawn on the de l'Isle projection with a negligible scale error. On the map of the Northwestern United States, included between latitudes 41 and 54 degrees north, the scale error at the top and bottom is less than 0.0035, or 0.38 centimeter in the entire width of the map. On the map of the Southeastern States, 24 to 39 degrees north latitude, the maximum error is about 0.0045, the total error in the width of the map about 0.32 centimeter.

Construction of Figure 3, A. The coordinates φ_0 and φ_2 of the curves drawn in the diagram could not be computed directly. They were obtained by a roundabout procedure of computation with given latitudes of standard parallels, interpolation, and graphic transformation of coordinates. A part of the principal interpolation diagram used is redrawn in Figure 3, *B*. A large number of curves computed for a wide range of mid-latitudes $(\varphi_1 + \varphi_2)/2$, with scale 0.990 at the mid-latitude, were plotted in the coordinates φ and k. In lower latitudes, these curves, within the error of computation and plotting, are tangent to the base ordinate, $k = 0.990$ in Figure 3, *B*. From about latitude 50 degrees poleward the descending limbs of the curves cross the base ordinate at the mid-latitude.

Use of the interpolation diagram required that the curves be tangent to the base ordinate at their minima. When so tangent at its minimum, each curve defined a latitude at which the scale is at a minimum by the latitude at which it was tangent, the latitudes of the standard parallels where it crossed the ordinate 1.000, and the limiting parallels where it crossed the particular ordinate where k had one of the values represented by the curves of k_σ in Figure 3, *A*. It was not necessary to draw an interpolation diagram for each of these values, since the curves plotted have the same shape regardless of the value of k at the mid-parallel. All that was necessary was to number the ordinates appropriately for each of the curves of k_σ in Figure 3, *A*.

In order to make the curves tangent to the base ordinate in the interpolation diagram, they were first plotted as computed, and then raised in the field of coordinates by adding to the plotted ordinates the distances by which they extended below the base ordinate at their minima. This process is illustrated in Figure 3, *B*, by the curve that when plotted from the computations crosses the base ordinate 0.990 at latitude 75 degrees. The computed curve is *a*, and *b* is the curve *a* when lifted until it is tangent to the base ordinate at its minimum. The minimum then falls at a latitude higher than the mid-latitude, as already appeared in Figure 2. This procedure is only an approximation; the rigorous procedure would have been to compute curves according to equation (5) with parameters such that their minima would fall at the base ordinate. Curve *c* of the three that have their minima

at latitude 85 degrees is such a curve; *a* of the same group is the computed curve that crosses the base ordinate at the mid-latitude, *b* is the same curve arbitrarily lifted until its minimum is at the base ordinate, and *c* is the curve computed from (5) with parameters that put its minimum at the base ordinate. Curve *b* evidently does not coincide with *c*, and so does not yield the same latitudes of the standard parallels and limiting parallels as does *c*. But the difference is appreciable only in very high latitudes; and the small gain in accuracy would not repay the labor of computing a large number of such curves as *c*. Their parameters would have to be found by trial, since the latitudes of their minima cannot be found by differentiating (5) and setting the derivative of k with respect to φ equal to zero. The differential of (5) is as intractable for such a procedure as (5) itself.

From the original working drawing corresponding pairs of latitudes of standard parallels and limiting parallels were read off and tabulated for each of the values of k_e represented by the curves in Figure 3, *A*. By graphic interpolation values of φ_0 and φ_2 were found for integral values of φ_1 and φ_2 at intervals of 5 degrees for each value of k_e represented. From these coordinates all three sets of curves in 3, *A*, could then be drawn.

The foregoing discussion of scale along the parallels of latitude has run on to such a length that the reader should perhaps be reminded that it refers to the de l'Isle projection, and to construction B only to the extent that differences between the two in scale on the parallels can be neglected. A mathematical investigation of scale on the parallels in construction B would be tedious, as are all mathematical inquiries into arbitrary geometrical constructions; and the information gained thereby could scarcely be expected to repay the effort. I shall therefore present only some qualitative and empirical considerations.

Let the reader imagine the net of parallels and meridians in a de l'Isle projection distorted into construction B. The standard parallel in the higher latitude φ_2 bends into an arc with a radius smaller than it had in the de l'Isle projection, and the standard parallel in the lower latitude φ_1 opens out into an arc with a larger radius than it had before the distortion. The other parallels separate slightly, except on the mid-meridian, arranging themselves at intervals on the meridians that are equal on the same meridian but larger than before distortion. On the standard parallels the meridians retain their intersections at their true distances apart, so that the scale on these parallels does not change.

The scale on the parallels other than the standard parallels is changed by the change in orientation of the meridians consequent upon the change in curvature of the standard parallels, on which the meridians are held at their true distances apart. The increased curvature of the standard parallel at φ_2 pulls the meridians toward the mid-meridian in the poleward part of the map, and the reduced curvature of the standard parallel at φ_1 pushes them away from the mid-meridian in the equatorward part. The amount of this displacement of the meridians increases from the mid-meridian outward toward the edges of the map. The meridians no longer converge toward a single point; those at a large departure converge toward

points on the prolongation of the mid-meridian closer to the map than the points of convergence of the meridians near the mid-meridian.

If the parallels other than the standard parallels retained the positions they had in the de l'Isle projection, this rotation of the meridians would change the spacing of the meridians on the parallels in such a manner that in the poleward part of the map the meridians would come closer together, reducing the scale along the parallels, and in the equatorward latitudes included in the map would move farther apart, increasing the scale along the parallels. But this consequence of the rotation of the meridians is counteracted by the change in curvature of the parallels, which assume a sharper curvature, thereby lengthening the arcs between meridians, in the poleward part of the map; and in the equatorward part straighten out, shortening the arcs between the meridians.

The question raised by these considerations is whether or not this compensation, which cannot be expected to be perfect, is sufficient to admit the formulation appropriate to the de l'Isle projection as a guide to the scale along the parallels in construction B. I submit the following empirical evidence: I have an unpublished map drawn according to construction B in the scale of 1 : 30,000,000, which includes a much larger range of latitude and longitude than is appropriate to the construction. The standard parallels are at 15 and 45 degrees of latitude, and the map extends over a range of departure in excess of 30 degrees. On this map I can detect with the dividers no difference in lengths of successive arcs of individual parallels out to departures of 30 degrees. At that departure the scale on the meridians exceeds that on the mid-meridian by more than 7 percent.

What has just been said refers to the constancy of scale along individual parallels at varying departures. Another question regarding the scale on the parallels is whether there is a significant change in relative scale among the several parallels as a result of the change from the de l'Isle projection to construction B. The following considerations bear on this question: (1) Since the scale remains true on the same two standard parallels as in the de l'Isle projection, and since in the range of latitude near them the scale varies toward higher and lower latitudes in the same sense as in the de l'Isle projection, the formulations based on the de l'Isle projection apply to the belts of latitude at the top and bottom of the map near the standard parallels, within the limited range of latitude and longitude to which construction B is appropriate. (2) The middle range of latitude, approximately halfway between the standard parallels, is the part of the net that is least affected by the change from the de l'Isle projection to construction B, with respect to both curvature of the parallels and rotation of the meridians. I conclude that within the range of latitude to which considerations of scale on the de l'Isle projection restricts its use, Figure 3, *A*, and the discussion based on it may be used without reservation as a guide to scale along the parallels in construction B.

Scale on the Meridians. In construction B, the two standard parallels are spaced at their true distances, reduced to the scale of the map, on the mid-meridian, but diverge with increasing departure. The length of the segment of any meridian

between the standard parallels is the length of a straight line between the two points at which the meridian intersects these parallels. Since the meridians are divided by the parallels into equal parts, the scale is constant along the full length of any one of them. The ratio h of the scale along any meridian at a given departure λ to the true scale along the mid-meridian—the relative scale on the meridian—may therefore be found as the ratio of the length of the segment of the meridian between the points in which it intersects the standard parallels to the length of the corresponding segment of the mid-meridian between the standard parallels.

The simplest means of obtaining the length of the segment of the meridian at departure λ is to use the familiar equation for the length of a segment of a straight line, d, between the points whose rectangular coordinates are, respectively, x_1, y_1, and x_2, y_2:

$$d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}. \tag{6}$$

In the simple conic development on which the polyconic tables are based, the coordinates of a point in latitude φ and departure λ are

$$x = \rho \sin(\lambda \sin \varphi),$$
$$y = \rho[1 - \cos(\lambda \sin \varphi)],$$

where ρ is the radius of the developed parallel reduced to scale. For present purposes it suffices to consider the earth as a sphere, so that

$$\rho = R \cot \varphi,$$

R being, as before, the radius of the sphere reduced to scale. Since only ratios are to be derived, R may be taken as unity.

In the polyconic tables, each parallel has its own origin of coordinates, at its intersection with the mid-meridian. In order to solve (6), however, a common origin for the two standard parallels is needed, which may conveniently be taken at the intersection of the standard parallel in the lower latitude, φ_1, with the mid-meridian. If derived from the sphere of unit radius, then, the coordinates of points on the parallel of latitude φ_1 are

$$x_1 = \cot \varphi_1 \sin(\lambda \sin \varphi_1), \tag{7a}$$

$$y_1 = \cot \varphi_1[1 - \cos(\lambda \sin \varphi_1)]. \tag{7b}$$

The abscissas of points on the standard parallel in the higher latitude, φ_2, are the same as when their origin of coordinates is at latitude φ_2; but the ordinates are increased by the length of the segment of the mid-meridian between the two standard parallels, $0.017453(\varphi_2 - \varphi_1)$, when the latitudes are expressed in degrees. The coordinates of points on the standard parallel of latitude φ_2 are, therefore, if the origin is at φ_1,

$$x_2 = \cot \varphi_2 \sin(\lambda \sin \varphi_2), \tag{8a}$$

$$y_2 = 0.017453(\varphi_2 - \varphi_1) + \cot \varphi_2[1 - \cos(\lambda \sin \varphi_2)]. \tag{8b}$$

The relative scale, h, along any meridian is then the ratio of the distance between

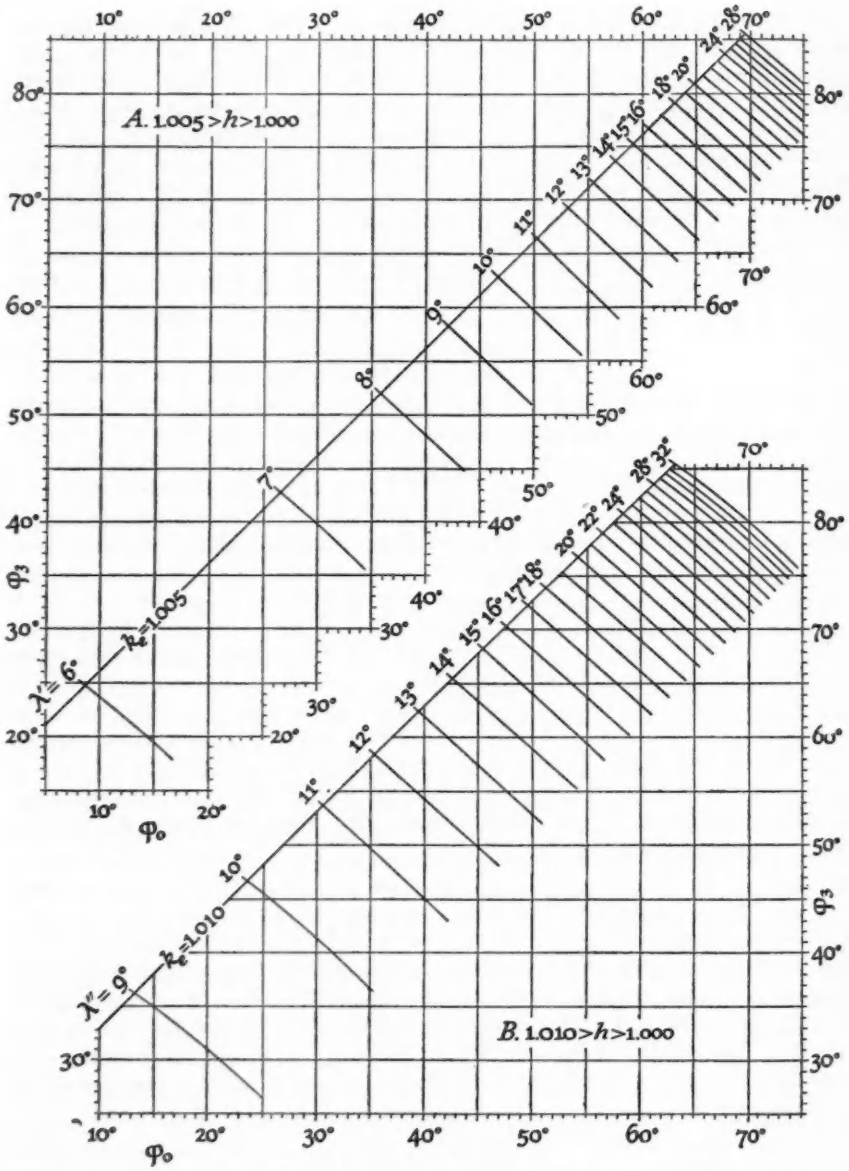


FIG. 4. Departures at which the relative scale on the meridian is: *A*, 1.005; *B*, 1.010, when the scale is true on the mid-meridian; construction B.

the standard parallels on the meridian to the corresponding distance on the mid-meridian:

$$h = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}/0.017453(\varphi_2 - \varphi_1), \qquad (9)$$

where the coordinates have the values given by equations (7) and (8).

Figure 4 is derived from equation (9), as Figure 3, *A*, is derived from equation (5). The steps from the equation to the diagram are nearly the same: computation for h for the necessary number of combinations of λ, φ_1 and φ_2; graphic interpolation for values of φ_1 and φ_2 corresponding to integral values of λ; plotting of curves of λ, φ_0, and φ_2 in coordinates φ_1 and φ_2; and graphic transformation of coordinates from φ_1, φ_2 to φ_0, φ_2 to obtain Figure 4. Since h depends on three variables, φ_0, φ_1, and λ, such a diagram as Figure 3, *A*, cannot be drawn. The two parts of Figure 4 contain, therefore, in coordinates φ_0 and φ_2, curves of integral values of longitudes λ' at which $h = 1.005$, and longitudes λ'' at which $h = 1.010$. The curves are cut off at the upper left by the curves of k_e, relative scale on the parallel, of the same value as the upper limiting value of h in the respective diagrams, repeated from Figure 3, *A*. The width of the belt on either side of the mid-meridian within which the scale error on the meridians does not exceed one percent, according to Figure 4, *B*, is slightly more than the 900 kilometers in the polyconic projection. An exact comparison cannot be made; but the average for the two limiting parallels is about 910 kilometers in low latitudes, and increases to about 950 kilometers at the upper limit of Figure 4, *B*.

The extent in longitude of a tolerable scale error when construction B is used may be found from Figure 4 for the areas cited earlier. A map of Alaska with limiting parallels 50 and 72 degrees north latitude, if the meridian of 150 degrees west is used as the mid-meridian, will have an exaggeration of scale on the meridians of less than one percent as far east as Juneau and as far west as Dutch Harbor. Greenland, with limiting parallels 59 and 84 degrees north, extends slightly beyond the limit of one percent in longitude as in latitude. The limiting parallels in a map of Scandinavia, 54 and 73 degrees north, permit an ample range of longitude with a scale error on the limiting meridians only slightly in excess of one-half percent at the eastern and western edges. Within the area covered by the National Geographic Society's map of the Northwestern United States, construction B permits a range of slightly more than 8 degrees of departure on each side of the mid-meridian with a scale error not exceeding 0.005, slightly more than 12 degrees with a maximum error of 0.010. The latter range is very nearly that included in the published map. At the eastern and western edges of the map of the Southeastern States, with its narrower range of latitude, the relative scale on the limiting meridians would be between 1.005 and 1.010. Thus in both the last two maps named the scale error at the right and left edges would exceed that along the top and bottom, if they were drawn in a net defined by construction B.

There remains, however, a refinement by which the range of longitude with a tolerable scale error on the meridians can be increased: reduction of scale on the mid-meridian to balance the exaggerations on the meridians at the sides of the map.

This is the adjustment proposed by Lallemand and used in the projection for the Millionth Map of the World.[6] Let the factor by which arcs of the mid-meridian are multiplied to reduce the scale on it be called a; a then will be the relative scale on the mid-meridian. Only one of the coordinates of the points on the standard parallels at which the meridian with departure λ intersects these parallels will be changed: the ordinate y_2, given by (8b), which becomes

$$y_2 = 0.017453\, a(\varphi_2 - \varphi_1) + \cot \varphi_2 [1 - \cos(\lambda \sin \varphi_2)]. \qquad (8c)$$

The relative scale on the meridians, h, increases from the mid-meridian outward with increasing departure, but starts at the mid-meridian from a instead of from unity. At some departure it becomes unity, and then continues to increase toward the sides of the map.

It does not seem worth while to carry out the computations needed for drawing such diagrams as A and B of Figure 4 for various values of a. The diagrams in Figure 4 suggest that most of that labor can be saved. The curves in the figure show that the limiting departures for a given value of h are nearly constant for constant values of $(\varphi_2 - \varphi_0)$. On the simplifying assumption that with $(\varphi_2 - \varphi_0)$ constant the mid-latitude $(\varphi_2 + \varphi_1)/2$ is also constant, it will suffice to investigate the variation of h with varying values of a, using a constant value of $(\varphi_2 - \varphi_1)$. I have used a value of 10 degrees for the difference in latitude between the standard parallels, which, as may be seen in Figure 3, B, corresponds to a difference of about 14 degrees in latitude between the limiting parallels at the top and bottom of the map. With this simplification, which does little violence to actuality, equation (9) gives, for each series of values of y_2 corresponding to a, a single series of values of h for varying values of departure λ.

Figure 5 shows the increment of departure gained by reducing the scale on the mid-meridian, with two limiting values of h, 1.005 and 1.010, at the edges of the map. If at the mid-meridian $h = a$, at the limiting meridians $h = (2 - a)$. In both A and B of Figure 5, one curve shows the departures at which h has the limiting value 1.005 or 1.010 when the scale is true on the mid-meridian, and another curve the departures when at the mid-meridian h equals a, a being, respectively, 0.995 and 0.990. The range of λ between the two curves in each diagram is the additional departure gained by reducing the scale along the mid-meridian by the same amount as it is exaggerated at the limiting meridians at the sides of the map. In a map of Alaska, with mid-parallel 62 degrees north, reduction of scale on the mid-meridian by 0.005 increases by 5 degrees on each side of the map the range of departure within which the relative scale does not increase beyond 1.005, thus by 10 degrees in all. The map may now extend over 35 degrees of longitude, from the easternmost part of the Panhandle to Nome, with a scale error on the meridians—exaggeration at the edges, reduction at the middle—of no more than ± 0.005. Ac-

[6] Ch. Lallemand, "Sur les déformations resultant du mode de construction de la Carte internationale du monde au millionème," *Comptes Rendus de l'Acad. des Sciences, Paris,* Vol. 153 (1911), pp. [559]–567.

cording to *B* of the figure, if an error of one percent is admissible, with mid-latitude 62 degrees, reduction of the scale by that amount on the mid-meridian permits inclusion of a band of 24 degrees of longitude on each side of it. A range of 48 degrees of longitude includes an area that extends from the southeasternmost part of the Panhandle of Alaska to 178 degrees west longitude, far enough to include

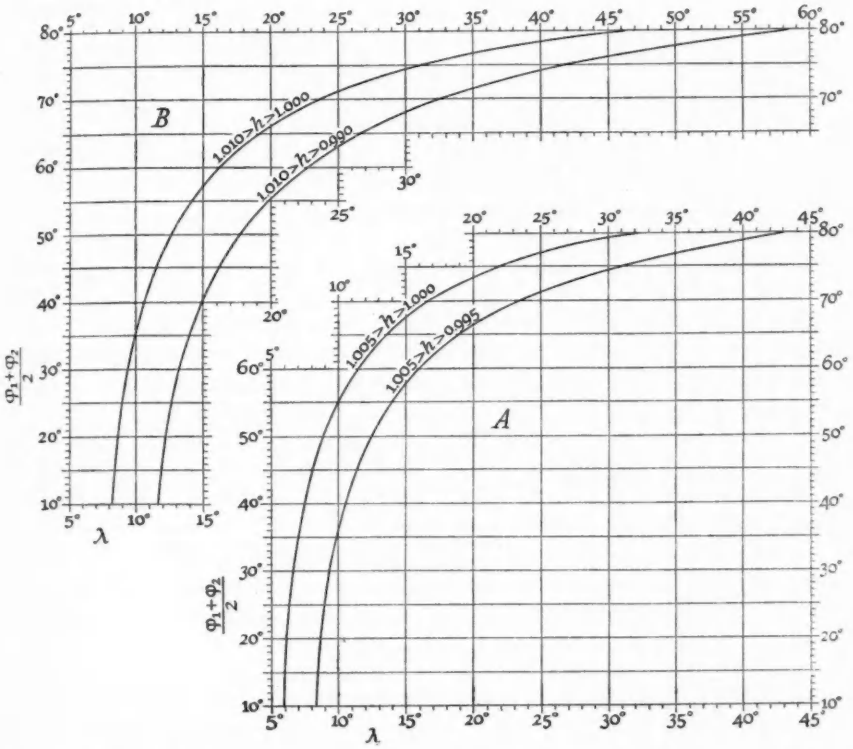


FIG. 5. Departure with tolerated exaggeration of scale on meridians, gained by reduction of scale on mid-meridian; construction B. Tolerated exaggeration, *A*, 0.005; *B*, 0.010.

the Andreanof Islands. Alaska is seldom mapped in one piece so as to include so much of the Aleutian chain.

Ordinarily, however, the question of selecting a projection for a map is not formulated in terms of two limits of tolerance of exaggeration of scale. What is given is the area, which is to be mapped with as little scale error as is practicable, given other circumstances that vary with the occasion. In the present instance one asks, with reference to the area to be mapped, "What is the factor *a* by which the scale on the mid-meridian is to be reduced so as to give the least scale error on the mid-

meridian and at the edges of the map?" Figure 6, *A*, is intended to answer this question. It is drawn in coordinates λ_e, departure of the meridians at the edge of the map, and mid-latitude. The curves are drawn for values of a at intervals of 0.001, but for 0.9985, 0.9995, and so on, so as to separate the fields in which the

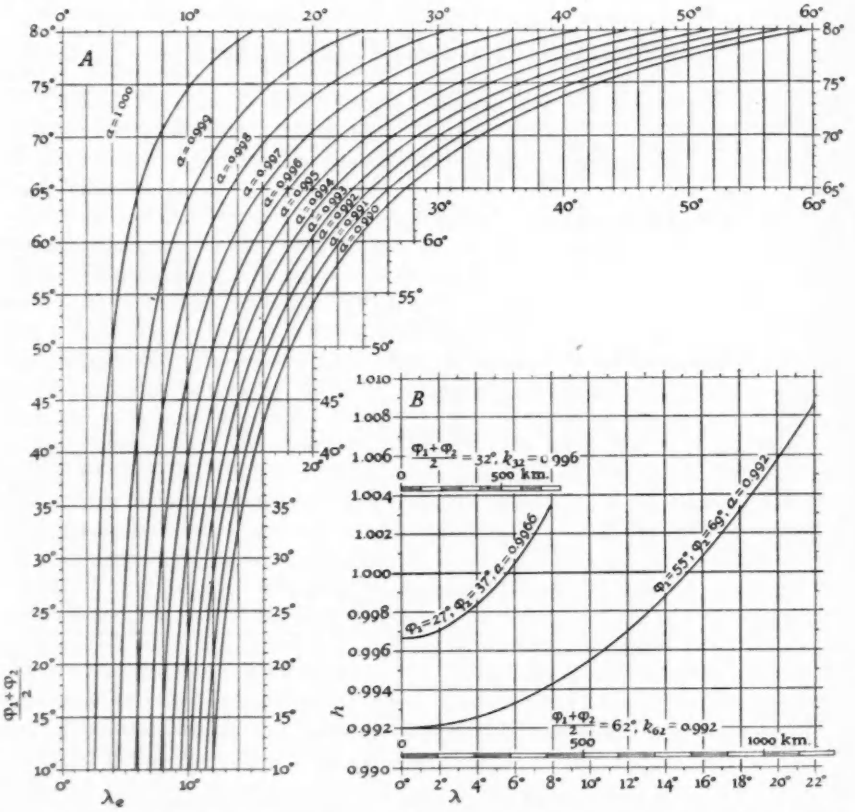


FIG. 6. *A*, factor a by which arcs of the mid-meridian are to be multiplied to give the least exaggeration of scale on the limiting meridians with given maximum departure; construction B. Abscissa, departure at the edge of the map; ordinate, mid-latitude. *B*, variation in scale along meridians at various departures with two values of a; construction B.

various values of a from 0.990 to 0.999 should be applied to the mid-meridian to give the exaggeration $(2-a)$ on the limiting meridians at the edge of the map. Consider Alaska again, with mid-latitude 62 degrees north, mid-meridian 150 degrees west, and limiting departure 20 degrees of longitude. The point in Figure 6, *A*, with coordinates $\lambda_e = 20$ degrees and mid-latitude 62 degrees falls in the area

where a is 0.993. (It is possible, but scarcely worth while, to interpolate to the fourth decimal of a.) The relative scale, h, at departure 20 degrees from the mid-meridian will then be 1.007. According to Figure 3, *A*, with limiting parallels 50 and 72 degrees, standard parallels 54 and 69 degrees, k is 1.009 at the limiting parallels and $(2.000 - 1.009) = 0.991$ on the parallel with the smallest scale. The scale error is thus fairly well balanced in latitude and longitude; and errors of this magnitude are admissible in all but exceptional maps of Alaska.

As for Greenland, with limiting parallels 59 and 84 degrees north, the appropriate standard parallels, according to Figure 3, *A*, are at latitudes 64 and 82 degrees; thus mid-latitude is 73 degrees. With a mid-meridian at 42.5 degrees west longitude, λ_0 is 30.5 degrees. According to Figure 6, *A*, the appropriate value of a is 0.994, so that the value of h at the limiting meridians is 1.006. Figure 3, *A*, shows that the scale error on the limiting parallels, with construction B, is more than twice as large. In a map of Scandinavia with mid-latitude 64 degrees and an extreme departure of 12.5 degrees, a is only 0.998. The exaggeration of scale on the limiting meridians is less than half that on the limiting parallels. In the area included in the National Geographic Society's map of Northwestern United States, with mid-latitude 47.5 degrees and limiting departure 13 degrees, a is 0.994. The exaggeration of scale on the meridians at the edges of the map, 0.006, is thus nearly the same as on the parallels at top and bottom, if the map were drawn on a projection according to construction B. The maximum error along the meridians is about 0.35 centimeter in the whole height of the map. In the area included in the Society's map of Southeastern United States, with mid-latitude 31.5 degrees and extreme departure 7.5 degrees, a is 0.998. The small exaggeration of scale on the meridians at the edges of the map is appreciably less than on the parallels at top and bottom, amounting to only 0.13 centimeter in the whole height of the map.

A few years ago I had occasion to draw a base map that included California, Nevada, Utah, Arizona, and narrow strips of the neighboring states and Mexico. I computed a transverse Mercator projection, which gave an exaggeration of scale at the edges of the map of only 0.0003. According to Figure 3, *A*, with limiting latitudes 31°45′ and 42°15′, standard parallels 33 and 41 degrees, the exaggeration in scale on the parallels at top and bottom, in construction B, would be 0.003. With mid-latitude 37 degrees and limiting departure 8 degrees, Figure 6, *A*, shows that a is 0.999, so that the exaggeration on the meridians at the sides of the map would be 0.001. In the whole width of the map, at the scale at which it was reproduced, the error in length along the mid-parallel and the extreme parallel would be ± 0.08 centimeter; that along the sides and the mid-meridian ± 0.02 centimeter. I doubt that anyone would use the map in such a way as to make these errors significant. Construction B would have required incomparably less time for computation, and less time in drawing as well, since the meridians are straight lines.

These examples may perhaps suffice to demonstrate the range of usefulness of construction B, when the scale error on the meridians is distributed by reduction of lengths along the mid-meridian by the factor a. It is not appropriate for maps

in which precision of scale is required. But most regional maps are not used for precise measurements; and this construction, which, I believe, requires less work than any other readily available for a wide range of scales and areas, suffices for many such maps.

Within tolerable scale limits, the error in angles is negligible. The angle γ between a meridian at departure λ and the mid-meridian is defined by

$$\tan \gamma = (x_1 - x_2)/(y_2 - y_1).$$

The same angle in a conic projection with parallels concentric about the point of convergence of the meridians, and thus with rectangular intersections between parallels and meridians, is

$$\gamma = n\lambda,$$

where n is the "constant of the cone," varying with the properties of the projection. It is sufficient for present purposes to set n equal to $\sin [(\varphi_1 + \varphi_2)/2]$. The "error in azimuth," θ, the angle by which the angle formed by a parallel and a meridian differs from a right angle, in construction B is therefore given by

$$\theta = \lambda \sin [(\varphi_1 + \varphi_2)/2] - \tan^{-1} [(x_1 - x_2/(y_1 - y_2)].$$

If Alaska is used as an example, and λ assigned the large value of 23 degrees, θ is only 52 seconds of arc. The distortion of angle varies, in addition, with the difference in scale between the parallel and the meridian at any point. A difference in scale between parallel and meridian as large as between 1.01 and 0.99 is probably near the maximum in maps drawn with attention to exaggeration of scale. With these two values, and neglecting the error in azimuth, Tissot's 2ω, the maximum distortion of angle, may be obtained from

$$\sin \omega = |h - k|/(h + k) = 0.02/1.99 = 0.0100.$$

Then ω is 34′23″, 2ω equals 1°05′. The distortion of angle resulting from the difference in scale between the parallel and the meridian can thus be expected to exceed one degree only if the scales on the parallel and the meridian differ by 0.02 or more at some point on the map. As for the error in area, $(hk - 1)$, where h and k refer to the same point on the map, within the magnitudes of regions for which the construction is likely to be used, this error will ordinarily be within the error of planimetry.

Figure 3 gives a notion of where the standard parallels lie in the range of latitude between the top and bottom of the map: at 70 to 80 percent of the distance from the mid-parallel, except in very high latitudes. The reader will wonder where the "standard meridians," at which $h = 1.000$, but which are not identified in the construction, lie in the range of longitude. The question is not very important, and as an answer I submit only the curves plotted in Figure 6, *B*. These curves show the variation in scale on the meridians (1) in the area included in the National Geographic Society's map of Southeastern United States, and (2) in Alaska: a narrow area in lower middle latitudes and a wide one in high latitudes. In each instance, the scale begins at the mid-meridian, departure zero, with the value of

a read from the diagram A of the same figure, and increases to $(2.000 - a)$ at the limiting meridians. In the former curve, the value of a is interpolated to four decimals, in the latter read to only three; the scales at the middle and at the edges of the map therefore balance better in the former than in the latter curve. It will be seen that the curves cross the ordinate where h is 1.000 at about 70 percent of the departure at the limiting meridians. The variation in scale with longitude is thus distributed approximately as with latitude. This distribution means that the scales on the parallels and meridians are most nearly equal at points on the diagonals of a map, the scale along both parallels and meridians being largest in the corners and least in the middle. The largest differences in scale between parallel and meridian are at the middles of the sides and of the top and bottom of the map, and larger in the middles of the long sides of elongated maps than on the short sides, or in the middles of the bounding lines of maps more nearly square.

This presentation of the properties of construction B has required many words, but the prospective user needs to refer only to Figures 3, *A*, and 6, *A*. Figure 3, *A*, entered with the latitudes of the extreme parallels of the area to be mapped, shows the least exaggeration of scale at these parallels that construction B permits, and the standard parallels to be used to yield this exaggeration. Figure 6, *A*, entered with the departure at the extreme meridians (half the total range of longitude) and the mid-latitude found from the latitudes of the standard parallels, gives the factor by which arcs of the mid-meridian are to be shortened to give the least exaggeration on the bounding meridians. The relative scale on the bounding meridians is $(2.000 - a)$. Provided with this information, a judgment can be reached whether or not the construction is appropriate to the task in hand. If it is found appropriate, the labor of computation and drafting the net of parallels and meridians is less, I believe, than is required in the construction of any other appropriate projection for regional maps of intermediate scale for which computed tables are not already available.

BOOK REVIEW STATEMENT

Beginning with the June issue the *Annals* will carry a special review section under the editorship of Norton Ginsburg of the University of Chicago. This section will be devoted primarily, but not entirely, to publications in geography and related fields which are of noteworthy methodological significance to geographers. In general, publications will be reviewed in terms of their contributions to the field of geography as a discipline and to those related fields in which geographers may have special interests.

The review policy will be highly selective and of necessity will be restricted to relatively few publications, excluding many which might be appropriate but for which reviewers might not be available or the general significance of which might not be clear. In general, reviews will be somewhat longer than most and will emphasize the conceptual, methodological, and theoretical significance of the materials under review rather than their descriptive substance. Undoubtedly, many publications will be reviewed not only in the *Annals* within the limits of this general policy but also in the *Geographical Review, Economic Geography,* the *Journal of Geography,* and the *Professional Geographer.* This should not be a serious problem since the nature of the reviews may be quite different and the opportunities for the reader to compare different views of the same publications should be valuable.

The Review Editor will draw upon the experience and knowledge of his colleagues at the University of Chicago and Northwestern University for advice concerning publications to be reviewed. However, every effort will be made to spread the reviewing function over the universe of geographers in this country and occasionally abroad. In addition, it is proposed to have some works in geography reviewed by informed non-geographers whose special scholarly interest may coincide with that of the geographer-author of the publication. In this way, it will be possible to gain some understanding of the ways in which non-geographers look at geographical publications and in turn to disseminate the works of geographers a little more widely among scholars in related fields.

The Review Editor will welcome any comments and suggestions with regard both to a review policy and to specific materials that might be reviewed for the *Annals.* Publications for review should be sent to the Review Editor.

NORTON GINSBURG, Review Editor
WALTER M. KOLLMORGEN, Editor